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HANDLING POTATOES FROM STORAGE TO PACKING LINE

Methods and Costs

Marketing Research Report No. 890

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

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By

PAUL H. ORR

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Washington, D.C. Issued March 1971

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 — Price 55 cents

PREFACE

This report is one of a group of reports to be issued on the results of research dealing with reduction of marketing costs for potatoes by developing more efficient work methods, equipment, operating procedures, and facilities for preparing potatoes for market.

The study was conducted under the general supervision of Joseph F. Herrick, Jr., investigations leader, and Lewis A. Schaper, agricultural engineer, Handling and Facilities Research Branch, Transportation and Facilities Research Division, Agricultural Research Service.

Part of the basic data for this study was developed by Leonard Pawski, industrial engineer, formerly of Transportation and Facilities Research Division.

The study was conducted at the Red River Valley Potato Research Center, East Grand Forks, Minn., and in selected storages and packinghouses in the area.

The author wishes to thank the storage and packinghouse operators who made their facilities available for study and the equipment suppliers who provided information on the various items of equipment.

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HANDLING POTATOES FROM STORAGE TO PACKING LINE

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By PAUL H. ORR, *agricultural engineer, Transportation and Facilities Research Division, Agricultural Research Service*

SUMMARY

Moving potatoes from the storage to the packing line involves handling millions of hundredweights (cwt.) of potatoes annually. Operators of potato storages and packinghouses are interested in improving methods of handling so that they can minimize their costs through effective utilization of labor, equipment, and facilities.

Labor and equipment costs were developed for selected methods of handling potatoes from storage to packing line from above- and belowground types of storages.

Costs per 1,000 cwt. for handling potatoes from the various types and sizes of storage with the selected handling methods and supply rates are given below.

Both the hand-forking and bulk-scooping methods, shown at selected rates, have potentials for lower costs if performed at maximum supply rates.

In general, as capacity of storage increases, cost per 1,000 cwt. of potatoes handled decreases. As the supply rate increases, cost per

Method of handling and type and size of storage	Cost per 1,000 cwt. with supply rate per hour of—		
	100 cwt.	200 cwt.	300 cwt.
	Dollars	*Dollars*	*Dollars*
Hand forking, deep bin:			
42,000 cwt.	50.74	43.02	45.17
60,000 cwt.	49.01	40.31	42.44
120,000 cwt.	47.30	37.23	37.32
Fluming, cross-alley:			
42,000 cwt.	31.31	23.73	21.75
60,000 cwt.	29.73	21.72	19.45
120,000 cwt.	28.11	19.38	16.61
Fluming, door-per-bin:			
42,000 cwt.	32.23	24.71	22.68
60,000 cwt.	31.18	22.99	20.68
120,000 cwt.	29.16	20.26	17.37
Fluming, deep bin:			
42,000 cwt.	32.98	25.03	23.23
60,000 cwt.	32.06	23.60	21.49
120,000 cwt.	30.37	21.22	18.56
Bulk scooping, cross-alley:			
42,000 cwt.	33.66	25.27	22.58
60,000 cwt.	29.33	20.91	18.18
120,000 cwt.	24.76	16.30	13.52

1,000 cwt. decreases, except for the hand-forking method at the rates given in the tabulation.

The type of storage had a small but consistent influence on cost in the fluming method of handling. These costs were lowest for the cross-alley storage, next lowest for the door-per-bin, and highest for the deep-bin.

At the supply rates given, fluming is lower in cost than hand forking for removing potatoes from a deep-bin storage at all levels of capacity. For removing potatoes from cross-alley storages at 60,000- and 120,000-cwt. capacity, bulk scooping is lower than fluming whereas fluming is lower than bulk scooping at 42,000-cwt. capacity.

INTRODUCTION

Most of the potatoes grown in the fall crop areas of the United States are placed in storages immediately after harvest. The storage period may range from a few weeks to several months. Moving the crop from storage to the packing line, where it is prepared for market, involves the handling of millions of hundredweights of potatoes annually.

Operators of storages and packinghouses are interested in minimizing the cost of handling these large volumes of potatoes. These handling costs may be held to a minimum by improving methods of operation to effectively utilize the available labor, equipment, and facilities at each particular plant.

Storage and handling requirements are determined to a large extent by the end use to be made of the potatoes. "Fresh" or "table" potatoes are those that reach the consumer in their natural form. Potatoes that are stored for supplying this market are referred to as "table stock." Potatoes that reach the consumer in such prepared products as chips, french fries, and flakes are called "processing potatoes," and those stored for this purpose, "process stock." The other end use of stored potatoes is for seed; potatoes stored for seed are referred to as "seed stock" or simply "seed."

Table stock and seed potatoes are maintained in storages where the temperature ranges from 36° to 40° F.[1] Processing potatoes are kept at temperatures ranging from 40° to 80° F.[2] Cooler storage temperatures required by table stock and seed may be maintained by a "shell-ventilation" system. Floor trenches may be available in the storage but are not required for distributing ventilation air. The warmer storage temperatures required by processing stock are provided through a system of ducts or floor trenches beneath the piles. These trenches provide "through ventilation" to the stored crop.

Because of these floor trenches, processing potatoes may be removed from storage with an in-trench conveyor. This method is not necessarily available to the operator of table stock and seed potato storages.

Table stock potatoes are removed from the bins principally by fluming.[3] Most handlers of seed and process potatoes, however, find this method of handling unsatisfactory and do not use it.

Requirements for preparation of potatoes for the fresh market have necessitated installation of stationary packing lines in table stock packinghouses. The simpler requirements for the preparation of process and seed stock, for the processor and the grower, respectively, allows the use of movable packing lines. The method of handling from the storage to the stationary packing line may be quite different from that used for supplying the movable one.

Objectives of the Study

This study will analyze selected methods of handling table stock potatoes from the storage to the packing line. A particular method selected might also be applicable to handling process or seed stock.

[1] EDGAR, A. D. SHELL VENTILATION SYSTEMS FOR POTATO STORAGES IN THE FALL CROP AREA. U.S. Dept. Agr. Market. Res. Rpt. 579, 43 pp., illus. 1963.

[2] TALBURT, W. F., and SMITH, O. POTATO PROCESSING. 475 pp., illus. AVI Publishing Co., Westport, Conn.

[3] Potato fluming is the conveying of potatos from one point to another by water flowing through a sluice or flume connecting the two points.

The purpose of this study was to: (1) Determine the comparative costs of moving different volumes of table stock potatoes from selected types of storages to the packing line at different rates of supply using specified methods of handling and equipment; (2) measure the relative efficiency of the handling methods as affected by volume handled, rate of supply, and storage layout; and (3) determine the kinds and amounts of equipment required for each method in each type of storage.

Types of Storage in the Red River Valley

Storage facilities in the Red River Valley vary from small, single-bin structures of about 20,000-cwt. capacity to large, multibin plants with as much as 425,000-cwt. capacity. There are two distinct categories of storage—above-ground and below-ground. The major types of above-ground structures in the valley are shown in figure 1. They are (1) arched roof, (2) cross-alley, (3) door-per-bin, and (4) pallet box. The below-ground storages are principally (1) drive-in, two-way entry and (2) hatch-filled, deep bin (fig. 2).

New or replacement construction is usually above-ground, but below-ground storage is still important in the valley. Several million hundredweights of potatoes are stored in below-ground structures each year.

Arched Roof

The arched roof storage (fig. 1) is a common above-ground type of storage in the valley. In general, it is arched rafter, wood-frame construction on a slab-on-grade floor.[4] The interior is mostly a large single-bulk storage bin with space used as a work area. A partition separates the areas.

Potatoes are received from the fields in trucks. During the filling operations, these trucks drive into the storage through the drive-in doors. A large bin loader unloads the truck and places the potatoes in storage to a depth of normally 14 to 16 feet. When the storage is being unloaded, the potatoes at the work area are removed first, with the unloading progressing into the large bin.

Cross Alley

A principal type of above-ground storage is the cross-alley structure (fig. 1). It has vertical walls approximately 20 feet high. The inside is partitioned into bins perpendicular to and on both sides of a wide center alleyway. Bin-filling operations originate from the cross alley in the single-door units and from either the cross alley or the outer doors of the multiple-door units. A large, cleated-belt bin loader is used to fill the bins to a pile depth of 14 to 16 feet normally. The potatoes are separated from the alleyway by removable bin boards. The cross alley is then either left empty or filled to within a few feet of the alley receiving door.

When the potatoes are to be removed from storage, the alleyway is either partly or completely emptied first. Then, the exposed individual bins are emptied. A small attached work or packing area is added to the structure where the cross alley is used for storage. The wide alleyway serves as a work area when it is not used for storage.

Door-Per-Bin

The above-ground multiple door (door-per-bin) storage (fig. 1) is a major type of potato storage. It is frequently used by cooperative storage firms. The advantage of easy, uncongested access to any one bin for loading and unloading is important where several growers rent or buy bin space from the firm.

The inside is partitioned into bins, each having a drive-in receiving door opposite the narrow access alley. Filling is similar to that of the cross alley except that the loading occurs only through the individual receiving doors for each bin. Removable bin boards keep the potatoes from the access alley which is not filled. The potatoes are removed from any bin through this access alley and transferred to a packing area at the end of the storage.

Pallet Box

The above-ground pallet box storage (fig. 1) is generally a clear-span structure with an attached packing or work area. The building normally has vertical sidewalls and enough in-

[4] UNITED STATES DEPARTMENT OF AGRICULTURE. POTATO STORAGE 20,000 CWT. ARCHED ROOF. U.S. Dept. Agr. Misc. Pub. 1057, 2 pp., illus. 1967.

BN-36868, BN-36870, BN-36869, BN-36867

FIGURE 1.—Above-ground types of potato storages in the Red River Valley: *A*, Arched roof; *B*, cross-alley; *C*, door-per-bin; and *D*, pallet box.

terior height to allow the pallet boxes to be stacked four high. In some areas stacking five high is done. Various arrangements of the boxes may be used within the storage area, but generally narrow access alleys are left between the major sections of stored boxes.

Potatoes are generally received from bulk trucks and transferred to the pallet boxes either in the work area or just outside the storage itself. A fork truck then transports the filled boxes to their designated location in the storage.

When the storage is being emptied, the fork truck transports the filled pallet boxes to the packing areas and hauls the empty boxes to a storage area.

Drive-In Deep Bin

The below-ground drive-in, two-end entry, deep-bin storage (fig. 2) has a lengthwise drive alley located 10 to 16 feet above the storage floor.[5] At each end of this drive alley are drive-in entrances. The interior is partitioned into bins having a pile depth of about 20 feet. The bins are perpendicular to and on both sides of the drive alley. Removable bin boards separate the bins from the upper and lower alleyways. Both the lower alleyway and the upper drive alley can be filled as part of the storage. A small work alley perpendicular to the drive alley remains open for packing operations and storing equipment on both the upper and lower levels.

Potatoes are received from bulk trucks in the drive alley. The bins and lower alleyways are filled by using either a flatbelt conveyor or a draper-chain conveyor with a canvas chute attached until the pile is at a level that can be reached with a small bin loader from the drive alley. This small bin loader is then used to finish filling and leveling the bins and to fill the upper drive alley.[6]

When emptying the storage, potatoes are removed either partly or completely from the alleys, then from the exposed individual bins.

[5] EDGAR, A. D. and LONG, T. E. POTATO STORAGE FOR THE RED RIVER VALLEY. N. Dak. Agr. Expt. Sta. Cir. 70, 4 pp., illus. 1944.

[6] PAWSKI, L. HANDLING POTATOES INTO RED RIVER VALLEY STORAGES—METHODS AND EQUIPMENT. U.S. Dept. Agr. Market. Res. Rpt. 471, 39 pp., illus. 1961.

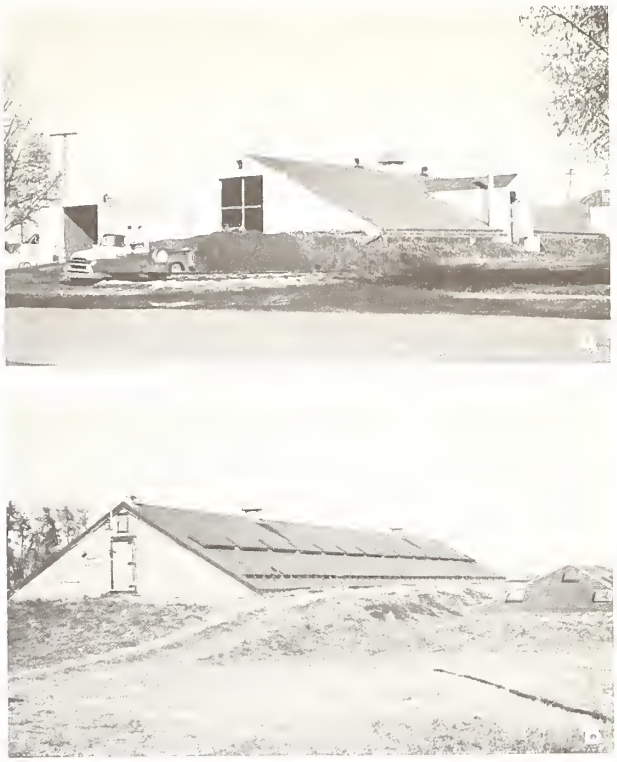

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FIGURE 2.—Below-ground types of potato storages in the Red River Valley: *A*, Drive-in, two-way entry, deep bin; and *B*, hatch-filled, deep bin.

Hatch-Filled Deep Bin

The hatch-filled deep bin (fig. 2) is basically the same storage as the drive-in deep bin without the drive-in feature. The same type of filling equipment is used, but the bin filling originates outside the structure and the potatoes enter the bins through hatches in the roof. The alleys are narrower in this structure than in drive-in deep bin and are generally not filled. Dormers provide a small work alley at the upper level.

Handling Methods and Equipment Used in the Red River Valley

The methods available for handling table stock potatoes from the storage to the packing line in the valley are (1) fluming, (2) hand forking to conveyors, (3) powered bulk scoop-

ing, (4) in-trench bin unloading, and (5) pallet box handling. Fluming is the principal method used. Hand forking to conveyors is used in the below-ground storages, and powered bulk scoop handling is new. The in-trench bin unloader and the pallet box system are not commonly used for these potatoes. All five methods are used for handling processing and seed potatoes although the use of water to move these out of bins is very limited.

Fluming

Potato fluming is the conveying of potatoes from one point to another by water flowing through a sluice or flume that connects the two points. The flume system must be so designed that the desired quantities of water and potatoes can be put into the flume at the receiving end and the potatoes taken out and the water disposed of at the other end.[7]

The system generally consists of (1) lateral flumes passing beneath the potato piles in the bins, (2) a main flume into which the laterals discharge, (3) a sump where the separation of potatoes and water occurs, (4) a conveyor or elevator which evenly feeds the potatoes to the packing line, (5) a centrifugal pump which recirculates the water, and (6) pipe and hose sections through which the water flows from the pump to the bins for sluicing. Through a simple arrangement of valves, the pump is also used to periodically flush out the dirt and debris deposited in the sump during fluming.

Using the rubber coil hose section of the system, a worker directs the flow of water at the bulk potato pile to flush the tubers into the open flume where flowing water carries them to the sump-elevator section of the system. As the work progresses, the worker removes the flume covers near the pile to expose the flume for receiving potatoes.

A typical layout of a flume system is shown in figure 3. Each unit of the system varies in size and capacity according to the rate of delivery desired.

[7] EDGAR, A. D., CLAYCOMB, R. S., and HANSEN, J. C. FLUME SYSTEMS FOR HANDLING BULK-STORED POTATOES. U.S. Dept. Agr. Market. Res. Rpt. 177, 16 pp., illus. 1957.

BN-36861

FIGURE 3.—A typical fluming operation in a below-ground potato storage.

Hand Forking to Conveyors

Workers at the bulk pile hand fork the potatoes onto nearby conveying equipment which is alined in such a way as to transfer the potatoes from the pile to the packing line.

The end of this conveyor line nearest the pile is the primary receiving point but workers may deposit forkfuls of potatoes at any section of the line. The primary receiving point often is a telescoping conveyor with a draper-chain unit to remove dirt (fig. 4). The telescoping feature permits the receiving end of the conveyor to be extended and retracted to keep it near the potato pile during forking.

The conveying equipment consists of (1) telescoping conveyor for maintaining proximity with the receding potato pile in the bin, (2) several sections of straight flat-belt conveyors which transfer forked potatoes from the telescoping conveyor at the bin to the line-feeding unit at the packing line, and (3) an elevator which receives potatoes from the straight sections and provides a uniform flow to the packing line.

The number of workers and conveyor lines depend on the rate of supply required at the packing line.

Bulk Scooping

This system requires the following equipment: (1) A powered bulk scoop to remove potatoes from bins and transfer them to the flow-regulating hopper; (2) a uniform-flow hopper to receive potatoes at this irregular rate of delivery and uniformly feed them to the packing line; and (3) a draper-chain elevator to lift potatoes from the hopper discharge to the packing line.

The powered bulk scoop picks up potatoes from the bins, transfers the loads to the receiving end of the packing line, and deposits them in a hopper. The scoop is loaded by directing it into the potato pile at the floor and raising the bucket up and away from the pile. Although various types of power scoops are available, the one generally used is a highly maneuverable, propane-fueled unit of about 1,000-pound lifting capacity (fig. 5).

A typical hopper unit is shown in figure 6. It should be large enough to hold several scoopfuls of potatoes and to provide a uniform flow to the packing line.

In-Trench Conveying

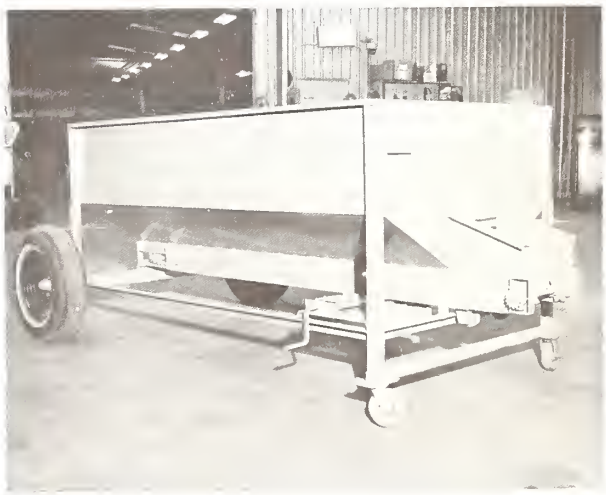
The basic unit in this system is a narrow, cleated-belt conveyor with flexible sides. This unit is placed in the air ducts which pass beneath the potato piles in the bins. The horizontal part of the unit fits into the duct to receive the tubers and the inclined section raises them 2 or 3 feet to the level of the hopper on the next item of equipment, usually the hopper of a movable grading table. Boards over the duct are removed individually as the unloading progresses, allowing the potatoes to flow from the pile onto the horizontal belt section. Most of the potatoes in the bin will flow to this conveyor, or they can be easily moved to it. Those remaining, however, must be hand forked to it. Progress is in approximately 6-foot intervals since the unit must be moved forward after all the potatoes immediately above and to the sides of the in-trench section are removed. A typical system is shown in figure 7.

BN-36871

FIGURE 4.—Hand forking to a telescoping conveyor.

BN-36862

FIGURE 5.—A typical powered bulk scoop.



BN-36864

FIGURE 6.—A typical hopper used with bulk scooping.

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FIGURE 7.—In-trench bin unloader and portable grader.

Pallet Box Handling

Pallet boxes of 1-ton capacity usually are stacked three- or four-high in the storage. An industrial forklift truck of about 3,000-pound capacity moves the boxes from the storage to the packing line. The box tipper at the packing line may be made up of either two sections of roller conveyors with a single tipper or two separate tipping units. In either case, an empty box can be removed and replaced while another box is being dumped.

The fork truck picks up and transfers pallet boxes from storage to the packing line and hauls the empty boxes to a storage area. Figure 8 shows a fork truck and pallet boxes in storage.

BN-36860

FIGURE 8.—Fork truck and pallet boxes.

RESEARCH METHODS AND TECHNIQUES

The research reported here was conducted at the Potato Research Center, East Grand Forks, Minn., and in selected storages and packinghouses in the Red River Valley.

Three principal handling methods—(1) hand forking to conveyors, (2) fluming, and (3) power scooping—were used in this research. Methods (1) and (2) are established ways of handling table stock potatoes from the storage to packing line; method (3) is a recent development.

Variables Considered

Variables selected as having an effect on the cost of a particular handling method were the (1) layout and design of the storage, (2) rate

of supply to the packing line, and (3) volume of potatoes handled.

The types of storage selected for study were: (1) Above-ground cross alley; (2) above-ground door-per-bin; and (3) below-ground drive-in, two-end entry, deep bin. Both of the above-ground types of storages had packing and work areas contiguous to the storage structures. The packing area in the below-ground type consisted of a work alley located at the same level with and perpendicular to the upper drive alley and a contiguous work area as needed. In these storages, the packing line was considered to be permanently located, requiring delivery of potatoes to a particular point.

The rates of supply to the packing line studied were (1) 100 cwt., (2) 200 cwt., and (3) 300 cwt. per hour per an 8-hour workday.

The volume of potatoes considered as being stored in and handled from each type of storage were (1) 42,000 cwt., (2) 60,000 cwt., and (3) 120,000 cwt.

The types and sizes of storage selected are identical to those reported in a previous Department publication, "Handling Potatoes Into Red River Valley Storages—Methods and Equipment" (see reference listed in footnote 6, p. 5).

The hand forking to conveyors method of handling was analyzed in the below-ground deep-bin storage only, as this method is used commercially in this type of storage.

Fluming was analyzed in all three types of storage—door-per-bin, cross alley, and deep bin—reflecting commercial practice.

The bulk-scoop handling method was analyzed in the cross-alley storage only. The physical layout of the door-per-bin storage prohibits bulk scooping, and commercial practice in the deep bin storage indicates no trend toward such handling.

Determination of Costs

To determine the correct type, size, and amount of equipment required, each handling system was completely designed on the basis of storage layout and rate of supply to the packing line. With these data, ownership costs for each handling system were developed.

The principal types of equipment used to move potatoes from storage were: (1) Flume system complete with flumes, sump, pump, pipes, and elevators for both above-ground and below-ground bulk storages; (2) conveyor system complete with telescoping conveyors, flat-belt conveyors, and elevators for use in the below-ground bulk storage; and (3) powered scoop, uniform-flow hopper, and elevator for use in the above-ground single-door, cross-alley storage.

Time standards were established to (1) determine the elapsed time required, (2) determine total man-hours of labor and total machine-hours of equipment use required, (3) determine where delays, wait time, and other nonproductive times occurred during the performance of operations, and (4) provide a basis for developing improved methods.

Time standards were set in accordance with approved techniques by (1) stop-watch time study, (2) standard data, and (3) predetermined motion time. These standards represent an average qualified worker working at a normal rate with allowances for fatigue and personal time.

From these data, total man-hours and machine-hours required to perform the handling operations by each specific method were found. Labor and operating costs were computed based on these time standards.

Ownership, operating, and labor costs as determined were the basis for the comparison of the handling methods.

PRINCIPAL FACILITY AND EQUIPMENT REQUIREMENTS

Sizes of Storage

For comparative purposes, each of the three types of storage was designed as a typical model. Bin layouts for the 42,000-cwt. size of each are shown in the section "Methods of Handling and Labor Requirements" (p. 12). Each handling system was also designed and

evaluated for each type of storage for the 60,000- and 120,000-cwt. capacities.

To obtain the 60,000-cwt. capacity, the 42,000-cwt. below-ground deep-bin storage was changed from 60 to 120 feet to 60 by 167 feet, and the number of bins increased from 18 to 26. Two layouts of 60 by 167 feet were placed side by side to obtain 120,000-cwt. capacity. Bins in this type of structure cannot be lengthened because of difficulty of filling or deepened because of possible increase in pressure bruises in potatoes for depths over 20 feet.

The above-ground door-per-bin storage was increased from 42,000- to 60,000-cwt. capacity by changing the dimensions from 74 by 112 feet to 74 by 160 feet and increasing the number of bins from 7 to 10. To obtain 120,000-cwt. capacity, dimensions were increased from 74 by 160 feet to 140 by 160 feet, but the number of bins remained unchanged at 10.

The above-ground cross-alley storage was increased to 60,000-cwt. capacity by changing the dimensions from 64 by 130 feet to 80 by 144 feet. The number of bins was increased from 8 to 10. To obtain 120,000 cwt., these dimensions were further increased from 80 by 144 feet to 80 by 275 feet, while the number of bins remained at 10.

Flume System

The flume system becomes an integral part of the storage floor. The slope and section of the flume must be such that there is neither undue settling of soil and clogging by potatoes nor high velocity to injure the potatoes. The bottom and sides of the flume should be as smooth as possible. (See reference listed in footnote 7, p. 6.)

Uniformity in slope of floor and flume, as well as in shape of flume, is necessary for adequate movement of potatoes and minimum water flow. When the floor slopes toward the flume, potatoes may be easily flushed into the flume without having the water spread to adjoining bins and alleyways. (See footnote 7, p. 6.)

Although flume slopes of 1:120 to 1:240 (1-inch drop to 120 inches or 240 inches of flume) have been used, the potato and water level remains nearly constant with a bottom slope of 1:180.

The flumes in each storage were designed within the following criteria: (1) Shape was as given by Edgar (footnote 7, p. 6); (2) starting depth of the laterals was 10 inches; (3) slope was 1:180; (4) a 1-inch drop was used at all 90° turns; and (5) a minimum of 1-inch difference was required in depth of the main flume below the laterals at their junctions.

Size of sump was determined by these general requirements: (1) The sump volume below the bottom level of the flume should equal the volume of water in the longest flume and pipe plus space for accumulation of dirt with a minimum of 1 cubic foot of sump per lineal foot of longest flume; (2) sump depth should be 6 feet; (3) minimum width of sump should be 5 feet; (4) when a draper-chain elevator is used, the length of the sump should accommodate the unit at a 35° angle in the above-ground storages and at a 45° angle in the below-ground storages; and (5) the length to width ratio should be less than 3:1. Dirt volume was based on 2 percent dirt by weight with the potatoes in the storage. One cubic foot of sump volume was considered necessary for every 100 pounds of dirt accumulated. Clean out was considered to be done daily. Sizes of pipes were chosen to reduce power requirements due to friction head while supplying the proper amount of water for each system. A static head of 10 feet was used in all systems. Friction head varied with the size of pipe and rates of supply used. Size of pump and motor was based on total head requirements and the chart given by Edgar (footnote 7, p. 6).

Aluminum irrigation pipe was used as the supply line. The lengths of the pipe section were such as to conveniently approach each bin opening. Snap-type connectors with gaskets and plugs were used. A rubber coil flexible hose was used for sluicing.

Iron pipe and valve arrangement at the pump and grating at the intake were designed as given by Edgar (footnote 7, p. 6). Sizes of pipes and valves varied with the rate of water supply. Cover boards for flumes were 2- by 8-inch dressed construction grade lumber.

The draper-chain elevator, which removes

the tubers from the water at the sump and transfers them to the packing line, was designed to operate at a 35° angle in the aboveground storages and a 45° angle in the belowground storage. The width of the unit varies from 18 to 32 inches depending on the supply rate of potatoes. The length is influenced by the depth at which the flume enters the sump. The unit is powered separately by an electric motor through the necessary gearbox and variable drive.

Conveyor System

The telescoping conveyor is a vital part of this system. It consists of an 11-foot flat-belt section and 11-foot draper-chain section which are joined at a pivot point. The draper-chain section can "telescope" 8 feet above the flat-belt section. This feature gives the conveyor unit a minimum length of 14 feet and a maximum of 22 feet. The conveyor belt is 18 inches wide. The unit can pivot about the connecting point as well as telescope. The assembly is powered by an electric motor and mounted on casters. The draper-chain unit provides for some dirt removal and serves as the initial deposit area for the forked tubers.

The straight flat-belt conveyors considered should be long enough to conveniently approach the bin openings, as well as provide the necessary length in series to reach the farthest point in the storage with a minimum number of units. They should also be maneuverable in narrow alleys. Lengths of 16 and 18 feet were found to be satisfactory. Each unit must be individually powered by an electric motor and mounted on casters. They should have a height adjustment at each end.

The draper-chain elevator was considered as part of the supply system. The elevator was designed for a 45° angle lift of the potatoes from the lower alley to the upper work alley (fig. 9). There they are transferred to another small draper-chain elevator which is also part of the supply system. The primary elevator is 25 feet long, and the secondary one is 6 feet long. The width of the elevator varies from 18 to 32 inches depending on the rate of supply. The flighted elevator chain is driven by 1½- to 3-hp. electric motors with appropriate gearbox and variable speed drives. The 6-foot secondary elevator is driven from the initial item of equipment usually a sizer, at the packing line rather than by a separate motor.

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FIGURE 9.—Typical draper-chain elevator used to transfer potatoes from lower to upper level in belowground storage.

Bulk-Scoop System

The primary unit of equipment is the powered bulk scoop. The unit considered was a 24-hp. propane-fueled four-wheel drive loader with a lifting capacity of 1,000 pounds (fig. 5). Its steering controls consisted of two levers which controlled the pair of drive wheels on either side. Boom controls were operated by foot pedals. The bucket had a struck capacity of 17½ cubic feet. An 8-inch backrail was installed on the bucket. The loading edges of the sides of the bucket were covered with 1-inch-diameter tubing.

A uniform-flow hopper is required to convert the intermittent supply of potatoes provided by the powered bulk scoop to a continuous uniform movement to the packing line. The hopper unit shown in figure 6 has an adjustable

inverted "V" trough directly above the conveyor chain in the hopper bottom which provides a relatively uniform flow of potatoes. The hopper, mounted on casters for ease in moving had a capacity of approximately 30 cwt. of potatoes.

METHODS OF HANDLING AND LABOR REQUIREMENTS

The types of equipment required by each method of handling are as described under "Principal Facility and Equipment Requirements" (p. 9). The required number of units of each item of equipment is given in the tables on annual equipment cost in the appendix.

Labor requirements for the 42,000-cwt. storage are itemized and show the development of the data. The same procedure was used for the 60,000- and 120,000-cwt. storages, but these data are not shown in this report. Only total labor and elapsed time are summarized for these sizes of storage.

For the specific supply rates, such as 100, 200, and 300 cwt. per hour, the flow rate is determined by the packing line with the crew pacing its activity to match the line requirements. For the maximum supply rates, however, the crews determine the flow rate.

Hand Forking to Conveyors in the Below-Ground Deep-Bin Storages

A typical layout and a cutaway illustration of a below-ground deep-bin storage of 42,000-cwt. capacity with hand forking to conveyors method of handling from the storage room are shown in figures 10 and 11.

The bins are filled to a depth of 20 feet. The lower alley is filled completely except for the short, perpendicular equipment storage alley. The upper drive has potatoes to a depth of 6 feet except for the perpendicular alley which is directly above the lower equipment storage alley. The packing line orginates in this upper alley space.

A draper-chain elevator transfers the potatoes from the lower area to the upper. A second short section of draper-chain elevator carries the potatoes to the packing line.

Labor Requirements

100 cwt. per hour, one crew, two forkers.—Table 1 shows the labor requirements to move 42,000 cwt. of potatoes, the capacity of the storage, from the storage to the packing line at a rate of 100 cwt. per hour with a 2-man crew. In this system, two workers perform the primary operations necessary to move the potatoes from the bulk piles to the packing line. A single worker from the packing line crew performs the secondary task of forking the potatoes left in the upper drive alley into the opening in the drive alley floor. The time required to perform this task is included in the unloading time. This forking is considered to be attended to in intervals of 4 feet intermittently as the lower alleys are unloaded.

During the primary supply operations, the forkers also move or reposition equipment and remove bin boards. All tasks involve both workers.

The operation of supplying the packing line consists of hand forking the potatoes from the bulk piles onto the telescoping conveyor.

The telescoping conveyor is moved by both forkers when necessary to keep it adjacent to the potatoes. The process generally involves extending the conveyor 4 feet at two different times, then retracting or "telescoping" the rear section 8 feet, and moving the entire unit ahead 4 feet. Straight flat-belt conveyors are added as needed to reach the hopper of the draper-chain elevator as the unloading progresses.

First the potatoes are removed completely from the longer alleyway, then the individual bins are unloaded starting at the far end of the alleyway and working back toward the perpendicular work alley. Two opposite bins are emptied before moving along the alleyway to the next pair of bins. Conveyors that are removed from the line are returned to the equipment storage area where they are again available for use when required. The shorter alleyway and associated bins are emptied and all

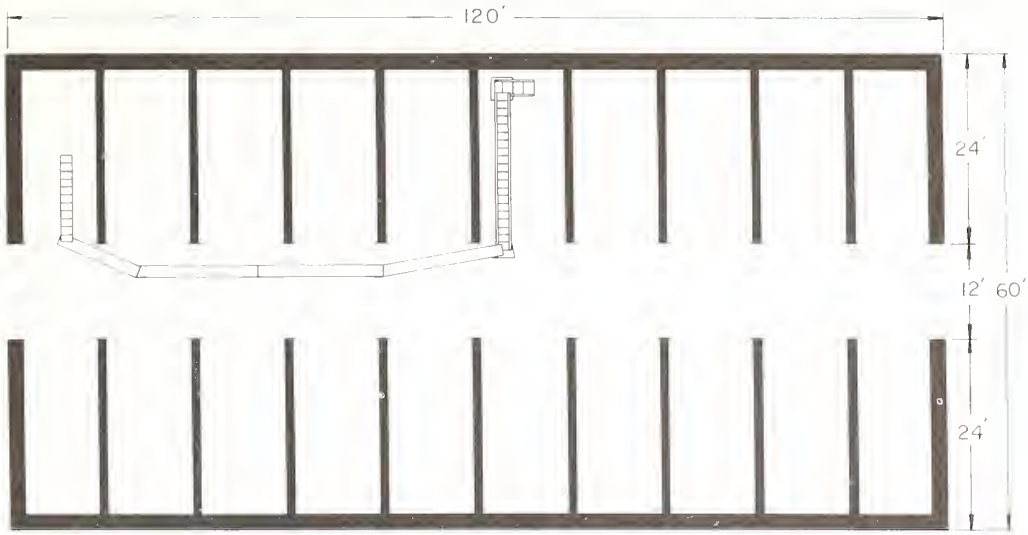

FIGURE 10.—Layout of the below-ground deep-bin storage of 42,000-cwt. capacity with a conveyor system for hand forking.

equipment is returned to the storage area. The entire storage is cleared of dirt and vines.

Occasionally, the conveyor line must be stopped to move accumulations of dirt from beneath the conveyors, rearrange power cables, adjust conveyor height, or clear vines or tubers that jam the belts on the conveyors. This time is called unavoidable delay. To reflect the effect of delays caused by conditions outside the system on the cost of the system itself, a factor for downtime at the packing line was used. Stoppages of the packing-line operations for a length of time that will require a stop of the supply system were set at 5 percent of the time required to move the total volume in storage at the rate of supply for each system. Delay time becomes more costly as the number of workers in a particular supply system increase, even though not directly caused by the handling system. This delay and that caused by the system itself is considered to be separate from the elements that affect the supply rate. In other words, all stoppages due to unavoidable causes will simply require additional man-hours of labor but will not affect the calculation of the flow rate of the supply operation.

Unproductive labor, however, does affect the efficiency of the systems. These items are due to conflicts in the forking operations between crews. Such items as wait time for one crew while the other arranges an item of equipment make up unproductive labor. Although the sequence of unloading the bin was chosen to avoid delays as much as possible, forking conflicts occurred. These conflicts are noted under unproductive labor. When the last bins are being emptied, any unbalance in the finishing time between crews is reflected here since the size of the bin permits only two forkers per bin.

A worker from the packing line was considered to be available for the required total time for forking potatoes through the slots in the upper alleyway. This time is a sum of several intervals of time required to blend the removal from the upper alleyway with that of the lower. This extra worker was required even though some crews were not working at maximum efficiency to insure that the line be supplied uniformly. As an example, had one of the two forkers supplying the line at 100 cwt. per hour stopped forking to the conveyors and gone to fork the potatoes from the upper drive, the line-supply rate would drop to approximately 75 cwt. per hour during his absence. The supply must be more uniform than that for proper utilization of labor at the packing line itself. An extra worker required only to move these potatoes through the slots would be unrealistic. A more practical approach is to

TABLE 1.—*Labor requirements to move potatoes from below-ground deep-bin storage of 42,000-cwt. capacity to the packing line by hand forking to conveyors at specific supply rates and sizes of crews*

Activity	100 cwt. per hour [1]			200 cwt. per hour [1]				300 cwt. per hour [1]			
	2-man crew	1 extra forker [2]	Total	2-man crew (No. 1)	1-man crew (No. 2)	1 extra forker [2]	Total	2-man crew (No. 1)	2-man crew (No. 2)	1 extra forker [2]	Total
	Man-hours	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Productive labor:											
Remove bin boards	3.52	0.21	3.73	2.86	0.38	0.21	3.45	1.76	1.76	0.21	3.73
Move equipment	1.57		1.57	1.49	.20		1.69	.86	.78		1.64
Supply packing line	834.91	7.49	824.40	415.58	209.42	7.49	632.49	277.38	277.38	7.49	562.25
Unavoidable delay [3]	67.20		67.20	33.60	16.80		50.40	22.40	22.40		44.80
Clean up	16.94		16.94	16.94			16.94	8.52	8.52		17.04
Total	924.14	7.70	931.84	470.47	226.80	7.70	704.97	310.92	310.84	7.70	629.46
Unproductive labor; wait for crew [4]	([5])	([5])	([5])	.07			.07		.08		.08
Total labor	924.14	7.70	931.84	470.54	226.80	7.70	705.04	310.92	310.92	7.70	629.54
Elapsed time (hours)	462.07	7.70		235.27	226.80	7.70		155.46	155.46	7.70	

[1] Based on sum of hours for the activities: Remove bin boards, move equipment, supply packing line, and unproductive labor.

[2] Worker from packing line crew forks 739 cwt. of potatoes to slot and removes bin boards in upper alley, balance of his time spent at packing line.

[3] 5 percent of operating time (total cwt. divided by the supply rate) due to downtime of packing line, plus 3 percent due to downtime of supply system.

[4] At 200 cwt. per hour, wait for crew No. 2 to move equipment; at 300 cwt. per hour, wait for crew No. 1 to complete forking.

[5] Not applicable.

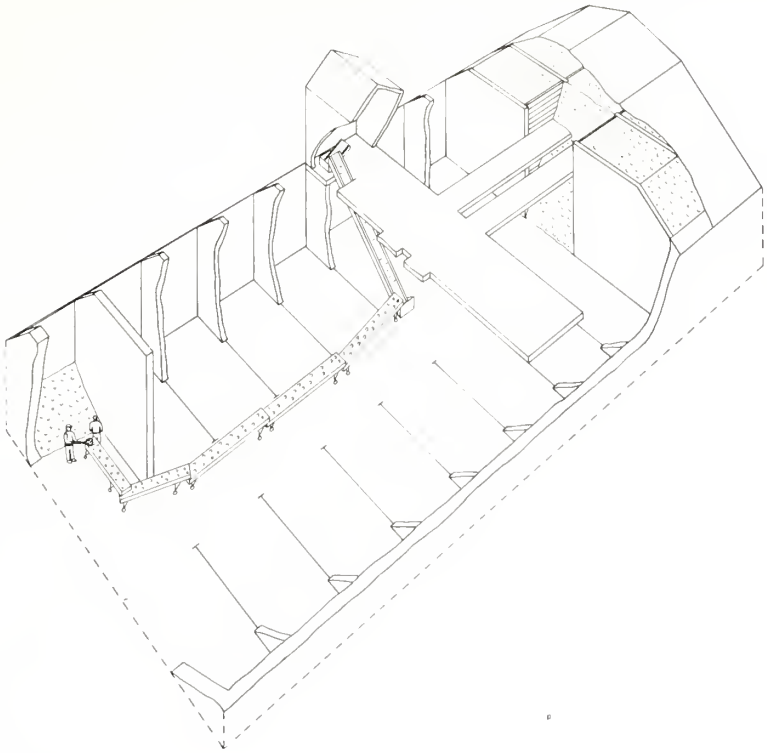

FIGURE 11.—Cutaway illustration of the hand forking to conveyors handling system and below-ground deep-bin storage of 42,000-cwt. capacity.

consider that a packing line worker can properly fit this function with others required of him at the packing line. This worker's labor is divided between the two functions as required.

200 cwt. per hour, two crews, three forkers. —Table 1 shows the labor requirements to move 42,000 cwt. of potatoes from storage with three forkers hand forking at a rate of 200 cwt. per hour. At this rate, fuller utilization of labor results in lower man-hour requirements for a given volume than for the 100 cwt. per hour rate.

Two forkers, working together as crew No. 1, perform essentially the same tasks and follow essentially the same procedure as was outlined in the labor requirements for the 100 cwt. per hour operation. The third forker works singly as crew No. 2.

The worker in crew 2 supplements the activity of crew 1 in such a way as to meet the supply rate of 200 cwt. per hour. Again, a worker from the packing-line crew performs the work elements required to move the potatoes from the upper drive alley to the lower storage alley as was described in the 100 cwt. per hour operation.

Crew 1 begins the unloading in the longer alleyway in the same way as described in the 100 cwt. per hour operation, while the forker in crew 2 begins unloading the shorter alleyway using a section of straight flat-belt conveyor. The worker in crew 2 removes all the potatoes that can be readily reached in the shorter alleyway with the single section of straight conveyor. He then leaves this conveyor in place and moves to crew 1's line of conveyors, opens a bin adjacent to the line, and forks potatoes directly onto the straight flat-belt conveyors to supplement the amount forked to this same line by crew 1. Approximately 1,200 cwt. are removed from each bin by the forker in crew 2. This is the amount that can be reached readily and will flow through the opening where the two lowest bin boards

are removed. This worker chooses the bins to be opened to insure having part of crew 1's conveyor line nearby. Crew 1 adds or removes straight flat-belt conveyors as required. Crew 1 completes removing bin boards and emptying bins from which the worker in crew 2 has removed about 1,200 cwt.

When the longer alleyway and adjacent bins have been emptied, the activities are repeated in the shorter end of the storage.

After all the potatoes have been removed and the equipment has been returned to the equipment storage area, crew 1 cleans the storage of dirt and debris.

Unavoidable delay is accounted for as in the 100 cwt. per hour operation. Unproductive labor results when crew 2 must stop forking and move the conveyor line across the alleyway to the full bins, and crew 1 must wait until this is completed.

300 cwt. per hour, two crews, four forkers.—The labor requirements to move 42,000 cwt. of potatoes from this same storage to the packing line at a rate of 300 cwt. per hour with two crews of two forkers each are shown in table 1. With this method, two forkers perform all elements together as crew 1, and two forkers work together as crew 2. This is basically a doubling of the method described in the labor requirements section for 100 cwt. per hour. Each crew forks to its respective telescoping conveyor and performs the work elements related to that equipment. At the 300-cwt. rate, the forkers work at almost full capacity and, therefore, require fewer man-hours than at the 100 or 200 cwt. per hour rate.

The operation begins as each crew moves its respective telescoping conveyor into position to empty the alleyways. Crew 1 begins forking from the longer alleyway while crew 2 begins from the shorter. All operations of each crew are as described in the 100 cwt. per hour—2-man crew section. However, to minimize the total number of conveyors required, crew 2 removes only enough potatoes from the shorter alleyway to expose a pair of bins, then it removes the potatoes from these bins before proceeding further into the alleyway. This procedure is repeated for each pair of bins. It allows crew 1 to complete removing potatoes from the longer alleyway and farthest bins and to release each conveyor before crew 2 needs the unit in its line.

Because of the difference in the number of bins to each side of the work alley, crew 2 must empty one of the bins in the longer alleyway. This is accomplished after the shorter part of the storage is completely emptied.

Again, a worker from the packing line moves the potatoes from the upper drive to the lower alleyway. Both crews perform the cleanup with this method.

Maximum rate of labor utilization.—Table 2 gives the labor requirements for the given method of forking to conveyors at rates of *maximum* labor utilization in the 42,000-cwt. capacity deep-bin storage. The rate of supply is based on the sum of the three elements of productive labor—remove bin boards, move equipment, and supply packing line—and the elements of unproductive labor. Removing boards, moving equipment, and unproductive labor occur during unloading in short intervals that momentarily delay forking. However, accumulating devices, such as hoppers in the line, will smooth out this intermittent supply and establish a fairly uniform flow.

Summary of Labor Requirements at All Supply Rates

Table 3 gives the labor requirements at all supply rates and for all sizes of storage considered with this method (p. 18). Two primary workers can supply the packing line with potatoes at a rate up to approximately 152 cwt. per hour from all three sizes of storage. Three forkers are required from approximately 152 cwt. per hour to approximately 227 cwt. per hour, and the two-crew four-forker supply team can provide potatoes up to approximately 304 cwt. per hour in all three sizes of storage. Thus, the 100 cwt. per hour rate will require one crew of two forkers, the 200 cwt. per hour rate, two crews with two forkers in one crew and one forker in the other, and the 300 cwt. per hour rate, two crews with two forkers in each crew. The 300 cwt. per hour rate closely approaches the maximum utilization of labor, approximately 98 percent. The 200 cwt. per hour rate reaches approximately 88 percent

TABLE 2.—*Labor requirements to move potatoes from a below-ground deep-bin storage of 42,000-cwt. capacity to the packing line by hand forking to conveyors at maximum supply rates for specific sizes of crews*

Activity	152.10 cwt. per hour [1]			227.43 cwt. per hour [1]				304.13 cwt. per hour [1]			
	2-man crew	1 extra forker [2]	Total	2-man crew (No. 1)	1-man crew (No. 2)	1 extra forker [2]	Total	2-man crew (No. 1)	2-man crew (No. 2)	1 extra forker [2]	Total
	Man-hours	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Productive labor:											
Remove bin boards	3.52	0.21	3.73	2.86	0.38	0.21	3.45	1.76	1.76	0.21	3.73
Move equipment	1.57	---	1.57	1.49	.20	---	1.69	.86	.78	---	1.64
Supply packing line	547.16	7.49	554.65	364.92	182.24	7.49	554.65	273.58	273.58	7.49	554.65
Unavoidable delay [3]	44.18	---	44.18	29.54	14.77	---	44.31	22.10	22.10	---	44.20
Clean up	16.94	---	16.94	16.94	---	---	16.94	8.52	8.52	---	17.04
Total	613.37	7.70	621.07	415.75	197.59	7.70	621.04	307.02	306.94	7.70	621.26
Unproductive labor, wait for crew [4]	(5)	(5)	(5)	.07	1.85	---	1.92		.08	---	.08
Total labor	613.37	7.70	621.07	415.82	199.44	7.70	622.96	306.82	306.82	7.70	621.34
Elapsed time (hours)	306.68	7.70	---	207.91	199.44	7.70	---	153.41	153.41	7.70	-----

[1] Based on sum of hours for the activities: Remove bin boards, move equipment, supply packing line, and unproductive labor.

[2] Worker from packing line crew forks 739 cwt. of potatoes to slot and removes bin boards in upper alley, balance of his time spent at packing line.

[3] 5 percent of operating time [total cwt. divided by the supply rate] due to downtime of packing line, plus 3 percent due to downtime of supply system.

[4] At 227.43 cwt. per hour, wait for crew No. 2 to move equipment and waiit for crew No. 1 to complete forking; at 304:13 cwt. per hour, wait for crew No. 1 to complete forking.

[5] Not applicable.

TABLE 3.—*Summary of all labor required to unload a below-ground deep-bin storage of various capacities by hand forking to conveyors at specified supply rates*

Capacity of storage	Crew size—2 primary forkers, 1 extra			Crew size—3 primary forkers, 1 extra			Crew size—4 primary forkers, 1 extra		
	Supply rate per hour	Total labor	Elapsed time	Supply rate per hour	Total labor	Elapsed time	Supply rate per hour	Total labor	Elapsed time
	Cwt.	*Man-hours*	*Hours*	*Cwt.*	*Man-hours*	*Hours*	*Cwt.*	*Man-hours*	*Hours*
42,000 cwt.	100	931.84	462.07	200	705.04	235.27	300	629.54	155.46
	152.10 (max.)	621.07	306.68	227.43 (max.)	622.96	207.91	304.13 (max.)	621.34	153.41
60,000 cwt.	100	1,335.33	661.75	200	1,011.33	337.75	300	903.43	222.90
	152.10 (max.)	891.43	439.80	227.17 (max.)	895.07	299.00	304.04 (max.)	891.93	220.02
120,000 cwt.	100	2,675.13	1,325.74	200	2,027.13	677.74	300	1,811.12	446.86
	152.07 (max.)	1,787.57	881.96	225.68 (max.)	1,805.92	604.00	303.97 (max.)	1,788.56	441.22

labor efficiency and the 100 cwt. per hour rate about 66 percent.

The level of labor utilization is also reflected in the total man-hour requirements shown in table 3. The supply rates that more closely approach full utilization of the crew require fewer man-hours to remove the same volume of potatoes.

Table 4 shows the labor requirements in man-hours per 1,000 cwt. When the labor provided in the supply system is fully, rather than partly, utilized, the man-hours per 1,000 cwt. is at its minimum. Approximately 15 man-hours per 1,000 cwt. are required when hand-forking potatoes to conveyors using the methods and facilities described. Size of storage has no significant effect on labor in the situations analyzed. Supply rate has an effect only to the extent of its utilization of the labor involved. With 300 cwt. per hour, full utilization is approached, 200 cwt. per hour somewhat less, and 100 cwt. per hour the least.

Fluming

Above-Ground Cross-Alley Storage

Figures 12 and 13 show a typical layout and a cutaway of an above-ground cross-alley storage of 42,000-cwt. capacity with a flume system. The potatoes are piled 14 feet deep in the bins and the alleyway is filled to within 10 feet of the receiving door. Removal of the potatoes starts at the packing area side of the alley where a bin doorway above the flume has removable bin boards that retain the potatoes.

Labor requirements for 100, 200, and 300 cwt. per hour.—Table 5 gives the labor requirements for supplying the packing line at various supply rates per hour with a flume system from an above-ground cross-alley storage of 42,000-cwt. capacity.

In this system, a single worker moves the potatoes from the bulk piles and through the flumes to the draper-chain elevator which regulates the flow to the packing line. This worker must maintain a supply of potatoes at the elevator. During this time, the worker can also open nearby bins, remove and replace flume covers, and clean and flush each bin as the emptying progresses. In addition, he must

supply a sufficient quantity of water to the sump once daily to operate the system. He does this by turning the necessary valves at the sump to start the water and stopping it when the correct amount is reached. Twice a day, he fills the flume system by turning the necessary valves to direct the flow of water into the pipes, starts the pump, and sees that the equipment is functioning properly while the system fills to operating capacity.

Assembling and disassembling of pipe are performed as unloading progresses. The flexible hose allows relatively long periods of operation without changes of pipe.

The packing line is supplied by directing the water to the base of the potato pile being moved so as to sluice the tubers from the pile into the flume where the flowing water carries them to the elevator. The operator opens the bins in the usual way and removes the flume cover boards to expose more flume as needed for removing potatoes. Occasionally the pile

TABLE 4.—*Total labor per 1,000 cwt. for hand forking potatoes from 3 sizes of below-ground deep-bin storages at 6 supply rates*

Capacity of storage	Supply rate					
	100 cwt. per hour	200 cwt. per hour	300 cwt. per hour	2-man (max.)	3-man (max.)	4-man (max.)
	Man-hours	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
42,000 cwt.	22.187	16.787	14.989	14.787	14.832	14.794
60,000 cwt.	22.256	16.856	15.057	14.857	14.918	14.866
120,000 cwt.	22.293	16.893	15.093	14.896	15.049	14.905

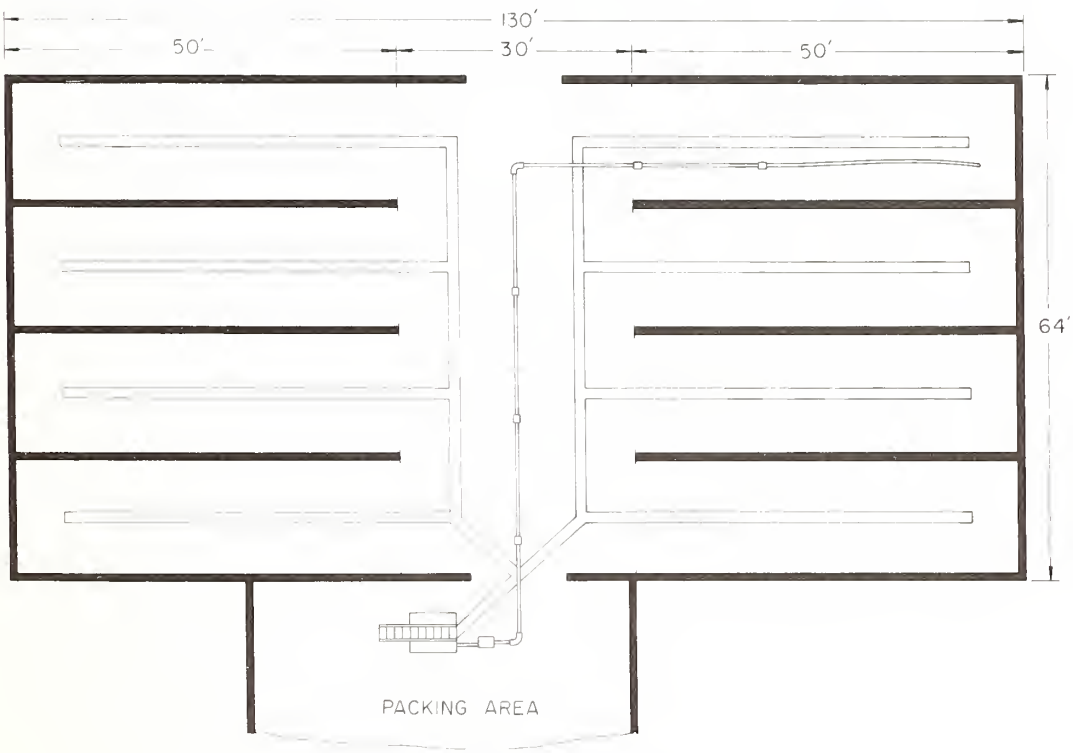

FIGURE 12.—Layout of an above-ground cross-alley storage of 42,000-cwt. capacity with a flume system.

TABLE 5.—*Labor required by 1 worker to supply the packing line by flaming potatoes from 3 types of storages of 42,000-cwt. capacity at various supply rates* [1]

Activity	Above-ground cross alley			Door-per-bin			Below-ground deep bin		
	100 cwt. per hour	200 cwt. per hour	300 cwt. per hour	100 cwt. per hour	200 cwt. per hour	300 cwt. per hour	100 cwt. per hour	200 cwt. per hour	300 cwt. per hour
	Man-hours	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Fill sump	3.00	1.54	1.03	3.98	2.03	1.35	2.34	1.19	.80
Assemble and disassemble pipe	.61	.68	.75	.72	.80	.88	.66	.74	.83
Fill flume system	4.20	2.12	1.40	5.90	2.98	1.97	3.03	1.53	1.01
Supply packing line	420.00	210.00	140.00	420.00	210.00	140.00	[2] 427.70	[2] 217.70	[2] 147.70
Unavoidable delay [3]	21.00	10.50	7.00	21.00	10.50	7.00	21.00	10.50	7.00
Clean out sump	25.63	18.98	14.04	27.86	19.54	14.35	26.45	19.18	14.02
Total labor	479.07	243.82	164.22	479.46	245.85	165.55	481.18	250.84	171.36
Elapsed time (hours)	479.07	243.82	164.22	479.46	245.85	165.55	481.18	250.84	171.36

[1] Based on the activity "supply packing line."
[2] Includes 7.70 man-hours of labor for 1 additional worker from packing line to fork potatoes to slot and to remove bin boards in upper alley.
[3] 5 percent of operating time due to downtime of packing line.

will tend to avalanche, resulting in an overload in the flume. When this occurs, the operator has time to perform other related tasks in the bin area, such as cleaning up, removing bin boards, and replacing flume covers until the flowing water has a chance to remove the excess tubers. The operator must watch the system and occasionally he might have to assist the movement of tubers by sluicing during the periods of overload.

Starting at the doorway to the packing area, the potatoes are removed either partly or completely from the alleyway, then each exposed bin is completely emptied. Sections of pipe are either added or removed when necessary as unloading progresses.

The operator cleans out the sump once a day by adjusting the proper valves at the sump and operating the pump to direct the flow of water from the sump to a disposal system. The operator hoses clean water directly into the sump to flush out dirt and debris from the equipment and sludge from the bottom of the sump. He removes vines and debris from the equipment and grate manually.

Above-Ground Door-Per-Bin Storage

A typical layout of an above-ground door-per-bin storage of 42,000-cwt. capacity with a flume system is shown in figure 14. A cutaway illustration of the storage and the handling system is shown in figure 15. The potatoes are piled to a depth of 14 feet in the bins. Removal starts directly from the bins through the access alley. In this type of storage, the unloading is considered to start at one of the end bins and progresses bin-by-bin to the other end bin. Each bin is assumed to be emptied completely before moving to the next.

Labor requirements for 100, 200, and 300 cwt. per hour.—Table 5 shows the labor requirements for emptying a door-per-bin storage of 42,000-cwt. capacity with a flume system when the packing line is supplied at rates of 100, 200, and 300 cwt. per hour. The operations are relatively the same as for moving potatoes from the bins to the packing line in the above-ground cross-alley storage.

Below-Ground Deep-Bin Storage

This storage is the same as that described

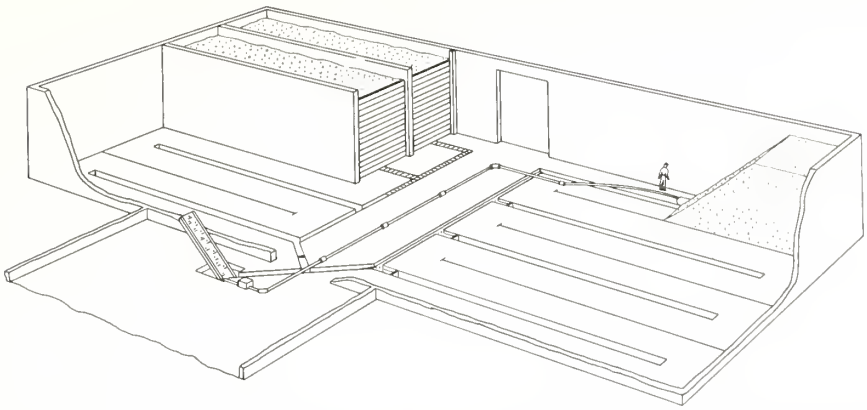

FIGURE 13.—Cutaway illustration of the flume system and an above-ground cross-alley storage of 42,000-cwt. capacity.

in the section "Hand Forking to Conveyors—Below-Ground Deep-Bin." Figure 16 shows the storage and flume layout and figure 17, a cutaway of the storage and handling system.

Labor requirements for 100, 200, and 300 cwt. per hour.— Labor requirements to flume potatoes in this type of storage are given in table 5. The potatoes can be removed from either the short or the long alley first. However, each alley is considered to be emptied to the end, then the bins on opposite sides of the alley are emptied as unloading progresses back toward the center of the storage. A worker from the packing line crew must fork the potatoes that do not flow down through the opening in the drive floor.

Summary of Labor Requirements for Three Types of Storages

The labor requirements are summarized in table 6 for the fluming method of handling in the cross-alley, door-per-bin, and deep-bin storages for all sizes of storages.

Each flume system is assumed to be operating at the assigned supply rate. The removal flow rate is determined by the system rather than by the flume operator. Thus, one worker can supply either 100, 200, or 300 cwt. of potatoes per hour, depending upon the capacity of the flume system. Production per man is higher as the capacity of the system increases and lower as it decreases.

The activities labeled (1) fill sump, (2) assemble and disassemble pipe, (3) fill flume system, and (4) clean out sump are labor items that do not affect the flow rate to the packing line. These activities are performed before or after packing line operations. For instance, the sump is filled to operating capacity once a day, and the flume system is filled twice a day. These activities are performed just before supplying the packing line. The sump is cleaned out just after the packing-line operation stops each day. The flume system has no unproductive labor. Unavoidable delay caused by the packing line is handled as it was in previous tables. There is no unavoidable delay attributed to the flume system.

Table 7 shows the labor requirements for fluming as man-hours per 1,000 cwt. in the specified storages at the various supply rates.

Because no additional workers are needed as supply rate is increased, man-hours per 1,000 cwt. decrease as the supply rate goes up. As in the conveyor system of handling, size of storage does not significantly affect labor required. Also labor requirements for fluming in the three types of storages considered do not differ much. The slight difference in labor because of a shorter flume system in the deep-bin storage is offset by the need for the extra worker from the washline to fork the potatoes from the upper drive. Thus, the labor requirements per 1,000 cwt. are very similar in the deep-bin, door-per-bin, and the cross-alley storages.

TABLE 6.—*Summary of labor requirements to supply 42,000, 60,000, and 120,000 cwt. of potatoes to the packing line by fluming from 3 types of storage at various supply rates*

Capacity of storage	Above-ground cross-alley storage			Above-ground door-per-bin storage			Below-ground deep-bin storage		
	Supply rate per hour	Total labor	Elapsed time	Supply rate per hour	Total labor	Elapsed time	Supply rate per hour	Total labor	Elapsed time
	Cwt.	*Man-hours*	*Hours*	*Cwt.*	*Man-hours*	*Hours*	*Cwt.*	*Man-hours*	*Hours*
42,000 cwt.	100	479.07	479.07	100	479.46	479.46	100	481.18	473.48
	200	243.82	243.82	200	245.85	245.85	200	250.84	243.14
	300	164.22	164.22	300	165.55	165.55	300	171.36	163.66
60,000 cwt.	100	682.17	682.17	100	690.74	690.74	100	690.24	678.41
	200	350.09	350.09	200	353.45	353.45	200	360.23	348.40
	300	235.63	235.63	300	237.63	237.63	300	246.37	234.54
120,000 cwt.	100	1,377.51	1,377.51	100	1,395.88	1,395.88	100	1,392.57	1,368.91
	200	704.97	704.97	200	712.90	712.90	200	723.82	700.16
	300	474.04	474.04	300	478.82	478.82	300	495.87	472.21

TABLE 7.—*Total labor per 1,000 cwt. for fluming potatoes from 3 types of storages at various supply rates, by capacity of storage*

Capacity of storage	Labor per 1,000 cwt.								
	Above-ground cross alley			Door-per-bin			Below-ground deep bin		
	100 cwt. per hour	200 cwt. per hour	300 cwt. per hour	100 cwt. per hour	200 cwt. per hour	300 cwt. per hour	100 cwt. per hour	200 cwt. per hour	300 cwt. per hour
	Man-hours	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
42,000 cwt.	11.406	5.805	3.910	11.416	5.854	3.942	11.457	5.972	4.080
60,000 cwt.	11.370	5.835	3.927	11.512	5.891	3.960	11.504	6.004	4.106
120,000 cwt.	11.479	5.875	3.950	11.632	5.941	3.990	11.605	6.032	4.132

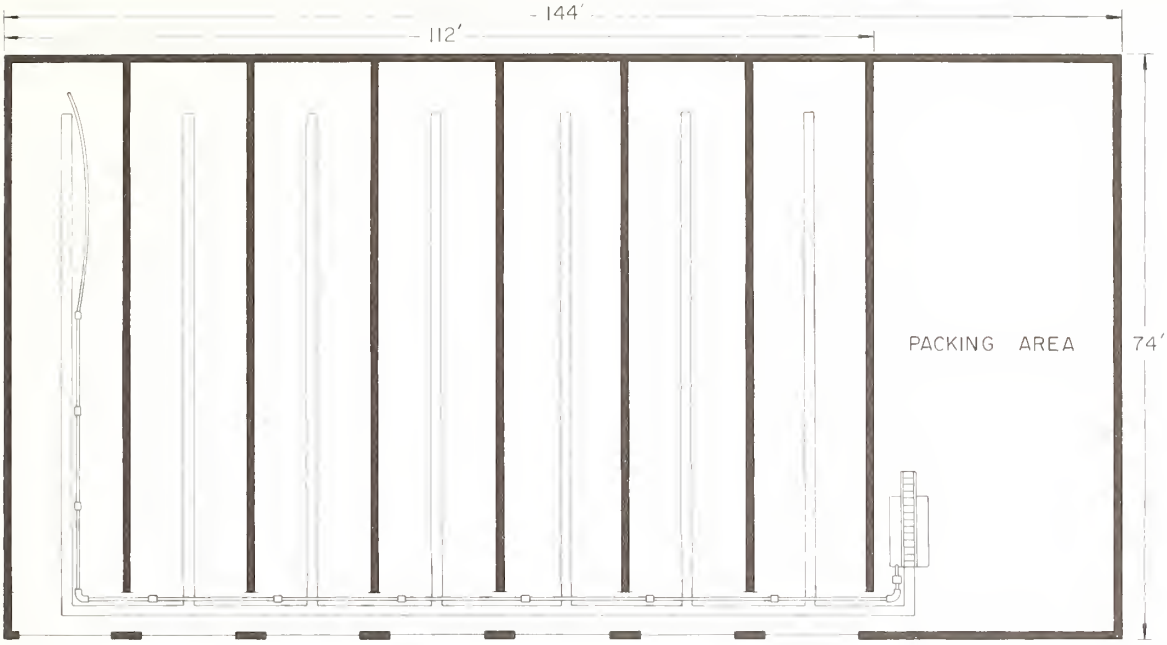

FIGURE 14.—Layout of an above-ground door-per-bin storage of 42,000-cwt. capacity with a flume system.

Bulk Scooping in Above-Ground Cross-Alley Storage

The storage layout is shown in figure 18. The storage arrangement when filled is the same as described previously for the fluming method of handling. The bulk-scooping equipment is shown in figure 19. The principal unit of equipment is the powered bulk scoop. The unloading begins at the packing room access to the cross alley; lower boards are removed so that the scoop can obtain a full load of potatoes.

Labor Requirements

100, 200, and 300 cwt. per hour.—The labor requirements to move 42,000 cwt. of potatoes from the the cross-alley storage with a bulk scoop is shown in table 8. The scoop operator is the only worker required.

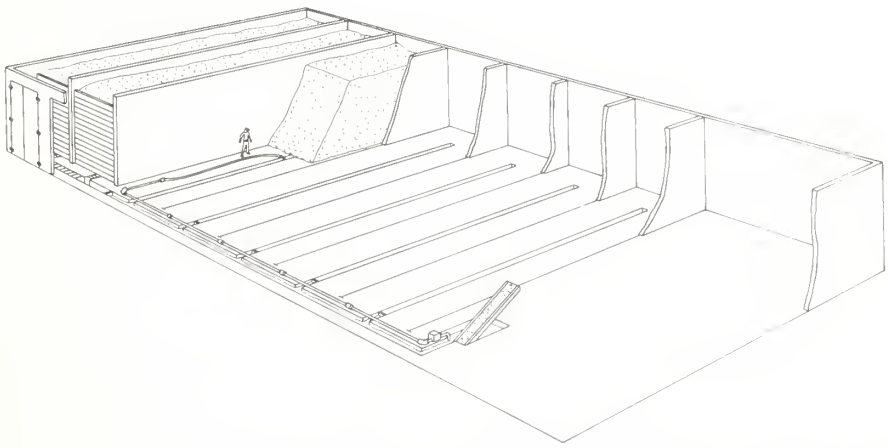

FIGURE 15.—Cutaway illustration of the flume system and an above-ground door-per-bin storage of 42,000-cwt. capacity.

Bulk-scooping potatoes generally involves (1) advancing the scoop toward the bulk piles with the scoop down to gather up tubers that may have fallen from previous loads, (2) directing the scoop into the sloping face of the bulk pile at the floor to obtain a scoopful of potatoes, (3) raising the scoop and simultaneously tilting it back to cradle the load, (4) turning the loader and moving forward to transport the load to the hopper, (5) tilting the bucket forward and lowering it at the hopper to deposit the potatoes into the hopper with a minimum drop, and (6) turning the

TABLE 8.—*Labor required by 1 worker to move potatoes from an above-ground cross-alley storage of 42,000 cwt. capacity to the packing line by bulk scooping at specified supply rates*

Activity	Supply rates per hour			
	100 cwt.[1]	200 cwt.[1]	300 cwt.[1]	700.12 cwt.[2]
	Man-hours	*Man-hours*	*Man-hours*	*Man-hours*
Productive labor:				
Set up and move equipment	0.11	0.11	0.11	0.07
Supply packing line	420.00	210.00	140.00	57.75
Remove bin boards	(3)	(3)	(3)	1.93
Unavoidable delay[4]	21.00	10.50	7.00	3.00
Total	441.11	220.60	147.11	62.75
Unproductive labor, change fuel tanks	(3)	(3)	(3)	.24
Total labor	441.11	220.60	147.11	62.99
Elapsed time (hours)	441.11	220.60	147.11	62.99

[1] Based on rates of supplying packing line.
[2] Based on sum of man-hours to supply packing line, to move equipment, to remove bin boards, and for unproductive labor.
[3] Not applicable.
[4] 5 percent of operating time due to downtime of packing line.

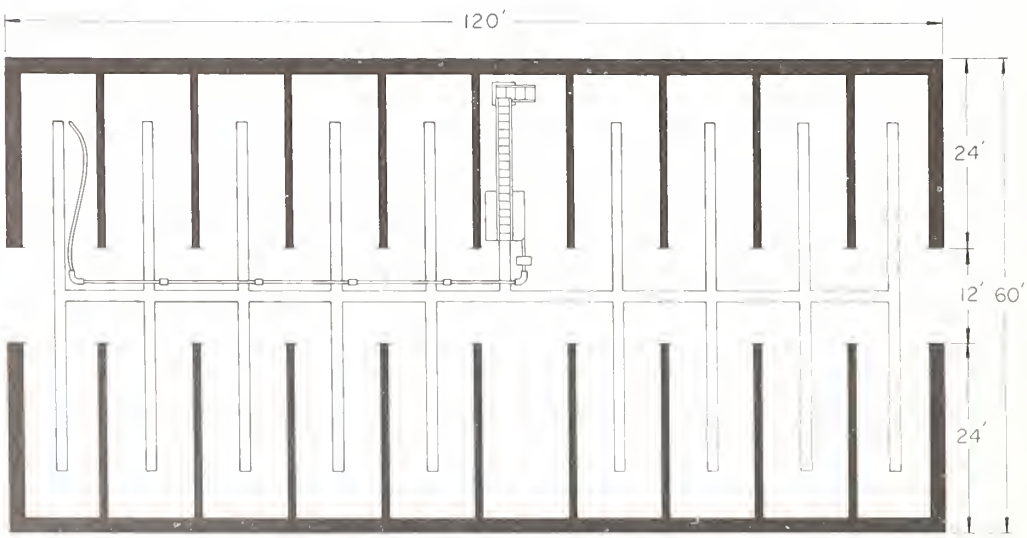

FIGURE 16.—Layout of the below-ground deep-bin storage of 42,000-cwt. capacity with a flume system.

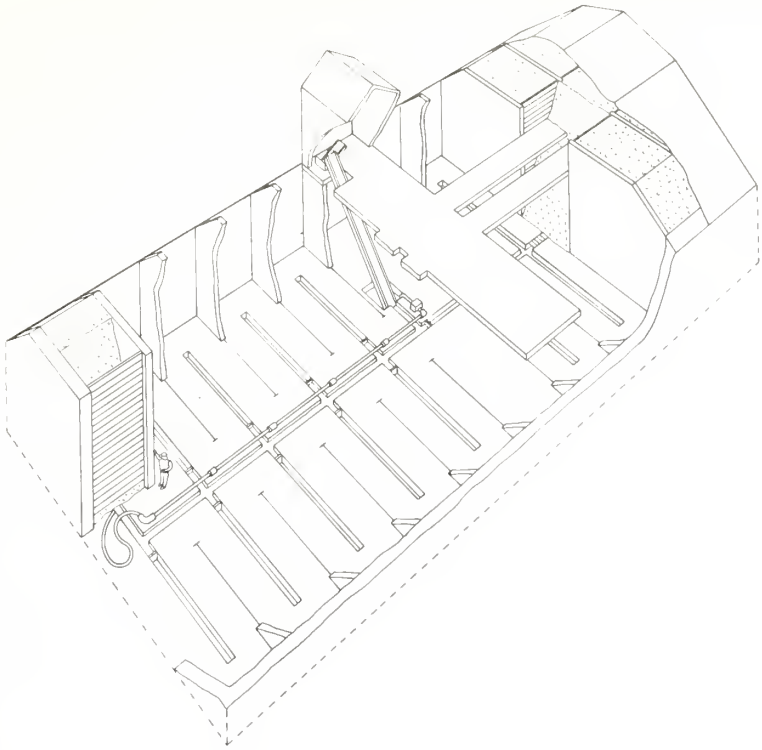

FIGURE 17.—Cutaway of the flume system and below-ground deep-bin storage of 42,000-cwt. capacity.

loader while lowering the bucket to repeat the cycle.

The item listed as "set up and move equipment" in table 8 involves the operator's time before beginning to scoop and again after part of the potatoes are removed from the cross alley. At first, the hopper is positioned with its length parallel to the cross alley. Later, when there is more room to operate, it is moved to a position perpendicular to the cross alley at the doorway.

Unavoidable delay caused by the packing line is again listed as 5 percent of the total volume divided by the rate of supply. This system has no unproductive labor.

The operator cleans up as the unloading progresses. When returning from the hopper to the piles, he keeps the scoop down on the floor to scoop up loose tubers and dirt.

Maximum rate of supply, 700 cwt. hour.—Table 8 gives the labor requirements for the bulk-scooping method at a rate of about 700 cwt. per hour in the cross-alley storage of 42,000-cwt. capacity. The rate of supply for the method is based on the sum of the three activities of productive labor—(1) remove bin boards, (2) move equipment, and (3) supply packing line—and unproductive labor. This maximum value represents the capability of the bulk scoop and operator with the assumption that neither the bulk hopper nor the packing line becomes a limiting factor. Because of the wide variation in the instantaneous rates of the unloading operation, this rate may not be practical. Initially, the scoop can supply the line at excessively high rates as the alley is unloaded, but when it must move to the more distant parts of the storage, the rate decreases markedly. Normally, the packing line would not be large enough to handle this initial high rate, thus becoming a limiting factor. The maximum rate does illustrate the capability of the bulk scoop to perform beyond the specific rates of 100, 200, and 300 cwt. per hour.

Summary of Labor Requirements at All Supply Rates

Table 9 summarizes the labor requirements for operating the bulk-scoop system in the cross-alley storages. At the specific rates of 100, 200, and 300 cwt. per hour, the supply rate is based on the activity "supply packing line" only. Opening bins, removing bin boards, and changing fuel tanks can all occur during unloading and will not delay the supply to the line. In determining the maximum rates, however, the line supply is assumed to be affected by these items because the operator must stop the scoop.

The worker's performance on the bulk scoop can affect the rate of supply. Therefore, fatigue and personal allowances are included in determining the production capability of the bulk scoop.

The same size of power scoop (p. 11) was assumed to be used for all sizes of storages because it is the size that is generally used commercially. The bulk hopper provides for different rates of flow through the feed and speed controls. Thus, the same size of unit can provide a uniform flow for a range of conditions, which is also standard practice.

Table 9 shows the man-hours per 1,000 cwt. needed to supply the packing line at the given rates from the three sizes of cross-alley type storages.

As with the flume system of handling, no additional workers are needed as the rate of supply is increased. Table 9 shows the decrease in man-hours per 1,000 cwt. of potatoes moved. Size of storage is not a factor at rates of 100, 200, and 300 cwt. per hour because the maximum rate for each size of storage is higher than each of these rates.

TABLE 9.—*Labor required for bulk-scooping potatoes to the packing line in 3 capacities of above-ground cross-alley storages at specified rates of supply*

Capacity of storage and supply rate	Labor	
	Total [1]	Per 1,000 cwt.
	Man-hours	*Man-hours*
42,000 cwt:		
100 cwt. per hour	441.11	10.503
200 cwt. per hour	220.60	5.252
300 cwt. per hour	147.11	3.503
700.12 (max.) cwt. per hour	62.99	1.500
60,000 cwt:		
100 cwt. per hour	630.11	10.502
200 cwt. per hour	315.11	5.252
300 cwt. per hour	210.11	3.502
643.50 (max.) cwt. per hour	97.90	1.632
120,000 cwt:		
100 cwt. per hour	1,260.11	10.501
200 cwt. per hour	630.11	5.251
300 cwt. per hour	420.11	3.501
514.54 (max.) cwt. per hour	244.88	2.041

[1] Elapsed time (hours) is identical to man-hours of total labor because only one worker is required.

Comparison of Labor Requirements of Three Methods

In the deep-bin type of storage, the hand-forking handling system is compared with the flume system. At the rate of 100 cwt. per hour, the labor requirement in man-hours per 1,000 cwt. is approximately double for the hand-forking system compared with the flume system. At 200 cwt. per hour, the labor requirement for hand forking is more than two and one-half times that of the flume system and at 300 cwt. per hour, approximately three and one-half times more.

The flume system and the bulk-scoop system can be compared in the cross-alley storages. Here the difference in labor is not so striking since only one worker is involved in each system. However, the bulk-scoop system shows less man-hours required by 9 percent at 100 cwt. per hour, by 11 percent at 200 cwt. per hour, and by 12 percent at 300 cwt. per hour than the flume system. Generally, this reduction in labor is due to bulk-scoop systems not requiring cleanup, pipe and sump filling, and pipe handling.

Type of storage has no real effect on the labor requirements of the flume system. This is noted when comparing manhours per 1,000 cwt. labor requirements in the deep-bin, door-per-bin, and cross-alley at all sizes of storage and at all supply rates analyzed.

Size of storage has no real effect on labor re-

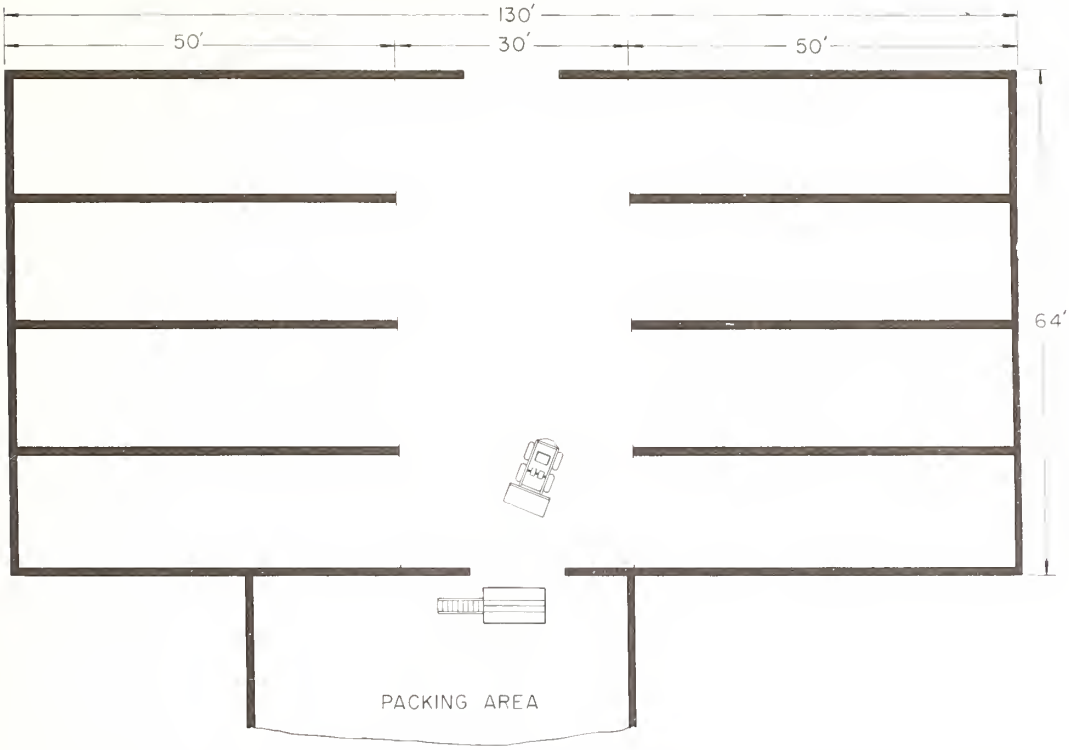

FIGURE 18.—Layout of the above-ground cross-alley storage of 42,000-cwt. capacity with a bulk-scoop system.

quirements within the types of storage, rates of supply, and sizes of storage discussed. One exception is the maximum rates at which the bulk scoop can operate in the cross-alley storage. Here size has a definite effect since the distance that the powered bulk scoop must travel from potatoes to hopper directly affects the average rate at which it can supply the line. Supply rates of 100, 200, and 300 cwt. per hour are lower than the maximum average supply rate of the bulk scoop in each size of storage; therefore, the effect of the size of storage does not show.

Supply rates within each type and size of storage and method of handling have an inversely proportional effect on labor requirements in the flume and bulk-scoop systems. As the supply rate doubles, man-hours per 1,000 cwt. is roughly halved, and as the supply rate triples, it is cut roughly a third.

However, in the hand-forking system as the supply rate moves from 100 to 200 cwt. per hour, the man-hours per 1,000 cwt. moves from approximately 22 to 17. This is still about three-fourths of the labor required at 100 cwt. per hour. The change from 100 to 300 cwt. per hour changes the man-hours per 1,000 cwt. from about 22 to about 15—or still more than three-fifths of the requirements at 100 cwt. per hour.

The slower rate of decrease in the labor requirements with the hand-forking system reflects the need for additional workers as the supply rate is increased. No additional workers are needed with either the flume or bulk-scoop systems.

Table 10 shows the labor costs for all the handling systems by sizes of storage and supply rates based on wage rates of $1.50 per hour. Both total cost and cost per 1,000 cwt. are shown. This table is simply a conversion from man-hours to dollars; no new data are indicated.

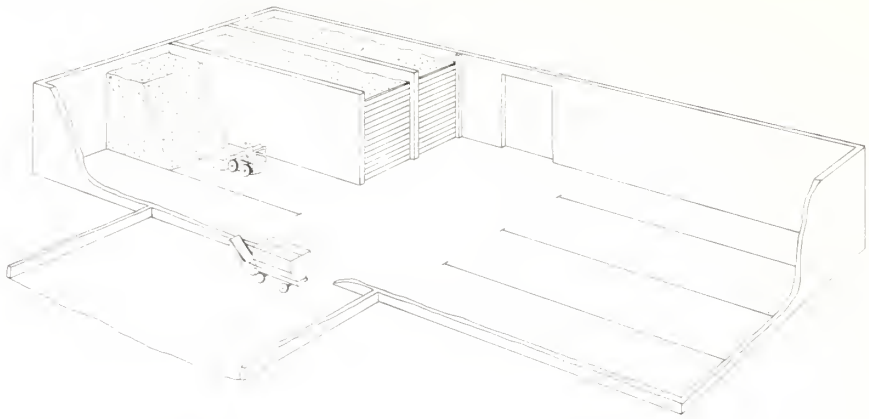

FIGURE 19.—A cutaway illustration of the bulk-scoop system and above-ground cross-alley storage of 42,000 cwt. capacity.

TABLE 10.—*Labor costs for different systems of handling potatoes from storage to the packing line, by type and size of storage*

Handling system and type and size of storage	Supply rate					
	100 cwt. per hour		200 cwt. per hour		300 cwt. per hour	
	Total cost	Cost per 1,000 cwt.	Total cost	Cost per 1,000 cwt.	Total cost	Cost per 1,000 cwt.
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
HAND FORKING						
Deep-bin storage:						
42,000 cwt.	1,397.76	33.28	1,057.56	25.18	944.31	22.48
60,000 cwt.	2,003.00	33.38	1,517.00	25.28	1,355.14	22.59
120,000 cwt.	4,012.70	33.44	3,040.70	25.34	2,716.68	22.64
FLUMING						
Cross-alley storage:						
42,000 cwt.	718.60	17.11	365.73	8.71	246.33	5.87
60,000 cwt.	1,023.26	17.05	525.14	8.75	353.44	5.89
120,000 cwt.	2,066.26	17.22	1,057.46	8.81	711.06	5.93
Door-per-bin storage:						
42,000 cwt.	719.19	17.12	368.78	8.78	248.32	5.91
60,000 cwt.	1,036.11	17.27	530.18	8.84	356.44	5.94
120,000 cwt.	2,093.82	17.45	1,069.35	8.91	718.23	5.99
Deep-bin storage:						
42,000 cwt.	721.77	17.18	376.26	8.96	257.04	6.12
60,000 cwt.	1,035.36	17.26	540.34	9.01	369.56	6.16
120,000 cwt.	2,088.86	17.41	1,085.73	9.05	743.80	6.20
BULK SCOOPING						
Cross-alley storage:						
42,000 cwt.	661.66	15.75	330.90	7.88	220.66	5.25
60,000 cwt.	945.16	15.75	472.66	7.88	315.16	5.25
120,000 cwt.	1,890.16	15.75	945.16	7.88	630.16	5.25

ANNUAL EQUIPMENT COSTS

Equipment costs were developed into two categories: (1) Ownership and (2) operational (see appendix).

Ownership Costs

Ownership costs for equipment for the three methods of handling are shown in table 11 as both total cost and cost per 1,000 cwt.

Conveyor System

The first part of table 11 covers the hand forking to conveyors method of handling in the below-ground deep-bin storages. The table shows that although total ownership cost increases as size of storage increases cost per 1,000 cwt. decreases. This increase in total cost at all three supply rates is due to the extra "length" of the conveyor line needed to reach to the more remote bins in the larger storages. On the basis of cost per 1,000 cwt., there is actually a decrease in cost in the larger storages because the extra volume of potatoes moved over this only slightly longer conveyor line more than offsets the slight increase in cost for the equipment.

The supply rate has a different effect; as the supply rate is increased from 100 to 300 cwt. per hour, both the total ownership cost and the cost per 1,000 cwt. increases. This increase is due to the use of wider conveyors and elevators and resulting larger motors required to handle the higher rate, as well as the extra units required when more than one crew is unloading. The lowest total ownership cost is for supply-

TABLE 11.—*Total ownership cost and cost per 1,000 cwt. for equipment to handle potatoes from storage to packing line, by handling system and type and size of storage*

Handling system and type and size of storage	Supply rate					
	100 cwt. per hour		200 cwt. per hour		300 cwt. per hour	
	Total cost	Cost per 1,000 cwt.	Total cost	Cost per 1,000 cwt.	Total cost	Cost per 1,000 cwt.
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
HAND FORKING						
Deep-bin storage:						
42,000 cwt.	514.14	12.24	615.90	14.65	821.10	19.55
60,000 cwt.	591.89	9.86	696.06	11.60	977.71	16.30
120,000 cwt.	825.11	6.88	937.73	7.81	1,280.11	10.67
FLUMING						
Cross-alley storage:						
42,000 cwt.	445.57	10.61	510.50	12.15	561.19	13.36
60,000 cwt.	541.30	9.02	607.60	10.13	657.44	10.96
120,000 cwt.	847.19	7.06	916.08	7.63	968.33	8.07
Door-per-bin storage:						
42,000 cwt.	476.24	11.34	543.26	12.93	594.29	14.15
60,000 cwt.	598.61	9.98	667.76	11.13	719.47	11.99
120,000 cwt.	908.79	7.57	987.04	8.23	1,035.33	8.63
Deep-bin storage:						
42,000 cwt.	474.36	11.29	535.41	12.75	597.70	14.23
60,000 cwt.	616.19	10.27	678.12	11.30	741.94	12.37
120,000 cwt.	989.10	8.24	1,053.06	8.78	1,121.63	9.35
BULK SCOOPING						
Cross-alley storage:						
42,000 cwt.	620.57	14.78	624.91	14.88	630.70	15.02
60,000 cwt.	620.57	10.34	624.91	10.42	630.70	10.51
120,000 cwt.	620.57	5.17	624.91	5.21	630.70	5.26

ing the packing line at 100 cwt. per hour from the 42,000-cwt. capacity storage. The highest cost is for supplying the line at 300 cwt. per hour from the 120,000-cwt. storage. On the basis of cost per 1,000 cwt., however, the lowest ownership cost is for supplying the line at 100 cwt. per hour from the 120,000-cwt. storage and the highest for supplying the line at 300 cwt. per hour from the 42,000-cwt. storage. For all sizes of storage, the lower supply rate results in lower ownership cost.

Flume System

Costs for equipment and per 1,000 cwt. in the fluming method of handling are shown for the cross-alley, the door-per-bin, and the deep-bin storages (table 11). As in the handforking system, the total ownership cost increases as size of storage increases at the three supply rates in the three types of storages. The cost per 1,000 cwt. decreases, however, because of the larger volumes handled. Of the three types of storages, the cross alley has the lowest equipment ownership costs. The reason for these lower costs is that it generally has a more efficient flume layout, requiring shorter lengths of flumes and pipe. These shorter lengths are reflected in smaller sump requirements also. The cross-alley and the door-per-bin do not require the long length of draper-chain conveyor that the deep-bin storage does to transfer the potatoes from bin floor to packing line.

Again, ownership costs increase as supply rate increases, reflecting the need for larger units of equipment to handle the higher rates of supply. The combination of size of storage and rate of supply that yields the lowest ownership cost per 1,000 cwt. with the flume system is the 120,000 cwt. cross-alley storage supplying the line at 100 cwt. per hour. The highest is the 42,000 cwt. deep-bin at 300 cwt. per hour.

Bulk-Scoop System

With the bulk-scoop method of handling from cross-alley storages, total cost of equipment remains unchanged as size of storage increases (table 11). The reason for this is that exactly the same equipment is used to feed the line at the various rates of supply for each size of storage. The cost per 1,000 cwt. decreases proportionately as the size of storage increases for each packing rate.

Ownership costs per 1,000 cwt. increase slightly as rate of handling increases because of the need of a wider conveyor to feed the packing line. The rest of the equipment has the capacity to meet the required supply rates listed without additional costs.

Summary of Ownership Costs

The lowest cost per 1,000 cwt. for equipment ownership of the handling systems discussed is the bulk-scoop system operating in the cross-alley storage of 120,000-cwt. capacity at 100 cwt. per hour. The highest is the hand-forking system in the 42,000-cwt. deep-bin supplying the line at 300 cwt. per hour.

In the cross-alley storage, ownership costs for fluming tend to be lower at each rate until the 120,000-cwt. capacity is reached, then bulk scooping is lower. A combination of high rate and high volume to be handled tend to make the ownership costs of the bulk-scoop system lower than flume system costs at the same rates and sizes of storage that were studied.

In the deep-bin storage, ownership costs for fluming are lower than hand forking except at the extreme combination of low supply rates and high storage capacity.

Operating Costs

Table 12 shows the operating costs for the three methods of handling as both total cost and cost per 1,000 cwt.

Conveyor System

In hand forking to conveyors in the below-ground deep-bin storages, both total operating cost and cost per 1,000 cwt. increase as size of storage increases at the supply rates studied (table 12). The reason for this is the need for extra equipment to reach the more remote bins. The rate of increase is lower, however, on the cost per 1,000 cwt. basis because the extra volumes being moved over the equipment tend to lower the effect of this extra equipment.

TABLE 12.—*Total operating costs and cost per 1,000 cwt. for equipment to handle potatoes from storage to packing line, by specified handling system and type and size of storage*

Handling system and type and size of storage	Supply rate					
	100 cwt. per hour		200 cwt. per hour		300 cwt. per hour	
	Total cost	Cost per 1,000 cwt.	Total cost	Cost per 1,000 cwt.	Total cost	Cost per 1,000 cwt.
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
HAND FORKING						
Deep-bin storage:						
42,000 cwt.	219.00	5.21	133.63	3.18	131.88	3.18
60,000 cwt.	346.04	5.77	205.38	3.42	213.45	3.56
120,000 cwt.	838.10	6.98	488.55	4.07	480.95	4.01
FLUMING						
Cross-alley storage:						
42,000 cwt.	150.80	3.59	120.25	2.86	105.97	2.52
60,000 cwt.	219.04	3.65	170.71	2.85	156.10	2.60
120,000 cwt.	459.72	3.83	351.96	2.93	313.63	2.61
Door-per-bin storage:						
42,000 cwt.	158.09	3.76	125.79	3.00	110.14	2.62
60,000 cwt.	236.35	3.94	181.20	3.02	164.81	2.75
120,000 cwt.	496.40	4.14	374.92	3.12	330.76	2.76
Deep-bin storage:						
42,000 cwt.	188.82	4.50	139.52	3.32	120.96	2.88
60,000 cwt.	272.28	4.54	197.31	3.29	178.16	2.97
120,000 cwt.	566.08	4.72	407.28	3.39	361.42	3.01
BULK SCOOPING						
Cross-alley storage:						
42,000 cwt.	131.40	3.13	105.37	2.51	96.92	2.31
60,000 cwt.	194.14	3.24	156.79	2.61	145.02	2.42
120,000 cwt.	460.05	3.83	385.35	3.21	361.52	3.01

As the supply rate increases, the operating cost decreases because of the shorter time needed to empty the storage. However, since utility rates are based on monthly charges, higher rates for the final period of operation can occur. The rate of 300 cwt. per hour requires only a short period of operation during the final month, and the resulting higher electric rate increases total operating cost.

Flume System

Cost per 1,000 cwt. for fluming from the door-per-bin cross-alley, and deep-bin storages increases slightly as size of storage increases (table 12). As supply rates are increased, the operating costs decrease in all three storages. This decrease in operating costs, in general, is due to less maintenance charge because of fewer operating hours.

The difference among the three types of storages in operating cost shows that the cross alley is slightly more favorable than the door-per-bin, and that the deep bin is the least favorable at all supply rates. The high cost for maintenance and power of the 25-foot-draper-chain elevator used with the deep bin affects this cost.

Bulk-Scoop System

As size of storage increases, operating costs increase at all packing rates in the bulk-scoop system (table 12). As packing rates increase, operating costs decrease within each size of storage. The lowest operating cost method is in

the 42,000-cwt. capacity storage at 300 cwt. per hour and the highest is the 100 cwt. per hour rate in the 120,000 cwt. storage.

Comparison of Annual Equipment Costs of Three Methods

The total annual equipment cost and cost per 1,000 cwt. for each size and type of storage for specified handling systems at the three specified supply rates are given in table 13.

In general, as size of storage increases, annual equipment costs increase, but costs per 1,000 cwt. decrease.

In the deep-bin storage, equipment costs for fluming are lower than hand forking at all rates and sizes studied. Fluming also tends to be the lower equipment cost method in the cross-alley storage up to 60,000-cwt. capacity at 200 cwt. per hour. At this point, bulk scooping and fluming show no difference in costs, but above this point and through the 120,000-cwt. capacity, the bulk-scooping method is lower in both total costs and cost per 1,000 cwt.

With the fluming method for all sizes of storage and for all supply rates, the three types of storages tend to reflect costs from lowest to highest—cross-alley, door-per-bin, and deep-bin, respectively.

TABLE 13.—*Total annual equipment costs for handling potatoes from the storage to the packing line, by handling system and type and size of storage*

Handling system and type and size of storage	Supply rate					
	100 cwt. per hour		200 cwt. per hour		300 cwt. per hour	
	Total cost	Cost per 1,000 cwt.	Total cost	Cost per 1,000 cwt.	Total cost	Cost per 1,000 cwt.
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
HAND FORKING						
Deep-bin storage:						
42,000 cwt.	733.14	17.46	749.13	17.84	952.98	22.69
60,000 cwt.	937.93	15.63	901.44	15.03	1,191.16	19.85
120,000 cwt.	1,663.21	13.86	1,426.28	11.89	1,761.06	14.68
FLUMING						
Cross-alley storage:						
42,000 cwt.	596.37	14.20	630.75	15.02	667.16	15.88
60,000 cwt.	760.34	12.67	778.31	12.97	813.54	13.56
120,000 cwt.	1,306.91	10.89	1,268.04	10.57	1,281.96	10.68
Door-per-bin storage:						
42,000 cwt.	634.33	15.10	669.05	15.93	704.43	16.77
60,000 cwt.	834.96	13.92	848.95	14.15	884.28	14.74
120,000 cwt.	1,405.19	11.71	1,361.96	11.35	1,366.09	11.38
Deep-bin storage:						
42,000 cwt.	663.18	15.79	674.93	16.07	718.66	17.11
60,000 cwt.	888.47	14.81	875.43	14.59	920.10	15.34
120,000 cwt.	1,555.18	12.96	1,460.34	12.17	1,483.05	12.36
BULK SCOOPING						
Cross-alley storage:						
42,000 cwt.	751.97	17.90	730.28	17.39	727.62	17.32
60,000 cwt.	814.71	13.58	781.70	13.03	775.72	12.93
120,000 cwt.	1,080.62	9.01	1,010.26	8.42	992.22	8.27

TOTAL COSTS OF EQUIPMENT AND LABOR

Table 14 gives the total annual costs for each supply situation studied.

TABLE 14.—*Total annual costs for handling potatoes from storage to packing line* [1]

Handling system and type and size of storage	Supply rate					
	100 cwt. per hour		200 cwt. per hour		300 cwt. per hour	
	Total cost	Cost per 1,000 cwt.	Total cost	Cost per 1,000 cwt.	Total cost	Cost per 1,000 cwt.
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
HAND FORKING						
Deep-bin storage:						
42,000 cwt.	2,130.90	50.74	1,806.09	43.02	1,897.29	45.17
60,000 cwt.	2,940.93	49.01	2,418.44	40.31	2,546.30	42.44
120,000 cwt.	5,675.91	47.30	4,466.98	37.23	4,477.74	37.32
FLUMING						
Cross-alley storage:						
42,000 cwt.	1,314.97	31.31	996.48	23.73	913.49	21.75
60,000 cwt.	1,783.60	29.72	1,303.45	21.72	1,166.98	19.45
120,000 cwt.	3,373.17	28.11	2,325.50	19.38	1,993.02	16.61
Door-per-bin storage:						
42,000 cwt.	1,353.52	32.22	1,037.83	24.71	952.75	22.68
60,000 cwt.	1,871.07	31.19	1,379.12	22.99	1,240.72	20.68
120,000 cwt.	3,499.01	29.16	2,431.31	20.26	2,084.32	17.37
Deep-bin storage:						
42,000 cwt.	1,384.95	32.97	1,051.19	25.03	975.70	23.23
60,000 cwt.	1,923.83	32.07	1,424.77	23.60	1,289.66	21.50
120,000 cwt.	3,644.04	30.37	2,546.07	21.22	2,226.85	18.56
BULK SCOOPING						
Cross-alley storage:						
42,000 cwt.	1,413.63	33.66	1,061.17	25.27	948.28	22.57
60,000 cwt.	1,759.87	29.33	1,254.36	20.91	1,090.88	18.18
120,000 cwt.	2,970.78	24.76	1,955.42	16.30	1,622.38	13.52

[1] Based on tables 10 and 13.

CONCLUSIONS

Within the limits of the types and capacities of storage, supply rates, and handling methods discussed in this report, the following conclusions were made.

1. As size of storage increases, total cost for handling to the packing line increases, but the cost per hundredweight handled decreases.

2. In general, as the rate of supply to the line increases, costs decrease. The exception is the hand forking to conveyors method in the deep bin where costs decrease as the supply rate increases from 100 to 200 cwt. per hour, then increase slightly as the rate increases to 300 cwt. per hour.

3. The effect of type of storage on fluming costs is small but consistently indicates that the lowest cost system is in the cross-alley storage. The door-per-bin is the next lowest cost system, followed by the deep bin.

4. Fluming is a lower cost method of handling from a deep-bin storage than hand forking to conveyors. Even if optimum supply rates

obtaining maximum labor utilization were used with the hand forking, the difference in costs between the two systems cannot be offset.

5. Bulk scooping is a lower cost method of handling than fluming from cross-alley storages of 60,000- and 120,000-cwt. capacity; in the 42,000-cwt. size, fluming is lower.

Cost factors such as used in this report are generally of primary concern in determining the desirability of a handling method. However, each system of handling has its unique characteristics that will affect its desirability for use in a particular storage-packinghouse situation. The packinghouse operator may be interested in the versatility of the method and equipment for other uses in his operation. He may also be concerned on the adaptability of the system to new situations.

The bulk-scooping and the hand-forking methods of handling, with their movable features, may have certain advantages. The bulk-scooping method is simple and lends itself to changes in size, layout, and supply rates. Equipment required by the bulk-scooping and hand-forking methods can also be used elsewhere in the storage and packinghouse operations.

Damage to potatoes was not evaluated, but the cushioning characteristics of water flowing in a well-designed flume system has appeal from that standpoint. The presoaking offered by the fluming may also be advantageous in areas where heavy soils tend to stick to the potatoes.

The availability of labor will directly affect the desirability of the hand-forking method of handling.

APPENDIX—MEASUREMENTS USED IN THE RESEARCH

Calculation of Labor Costs

Estimates of labor costs were made for the various combinations of handling method, supply rate, type of storage, and size of storage. The number of workers needed and the time required to perform the various activities were determined on the basis of total emptying of each storage. Total man-hours and total elapsed time were obtained. From total man-hours, wage rate, and storage capacity, total labor cost and labor cost per 1,000 cwt. were obtained for each handling method.

A wage rate of $1.50 per hour was set as one commonly used in the valley area in 1966.

When possible, actual commercial operation were studied. However, when the synthesized method required a particular activity that could not be obtained in a commercial operation, this activity was set up and studied under noncommercial conditions in storage facilities at the research center.

Time study techniques were used to determine the base time for performing the elements of work. These base times were then adjusted for fatigue and personal allowances as follows:

	Fatigue allowance
	Percent
Remove bin boards	15
Move conveyors (2-man crew)	15
Move conveyors (1-man crew)	20
Reposition conveyors	5
Fork potatoes	25
Shovel dirt	25
Move and dump loaded wheelbarrow	15
Operate powered bulk scoop	5
Move bulk hopper	15
Assemble and disassemble pipe	10
Clean out sump	15

A personal allowance of 5 percent was used for all elements of work.

The following descriptions of the various work elements are given to provide more detail concerning the work activities in the three handling methods than could readily be included in the tables.

Hand Forking to Conveyor

Remove bin boards.—Begins when workers place hands on bin boards to remove them after stopping such activities as moving equipment, forking potatoes, or working at packing line (extra forker) and approaching bin or alleyway for opening. Consists of unbolting re-

movable cleat, removing, carrying, and setting aside each board individually. Ends when the required number of fronts are removed and set aside.

Move equipment.—Begins when workers walk toward the equipment to be moved after stopping such activities as opening bins or forking potatoes. Consists of walking from place of previous activity to conveyors and moving them into or out of position in the line; repositioning equipment already in the line; moving equipment from and to the equipment storage area; and walking to the place of the next activity. Ends as forking, bin board removal, or cleanup starts.

Supply packing line (fork potatoes).—Begins when the workers pick up the forks. Consists of obtaining fork load of potatoes from the bulk piles; emptying the loads on the conveyors (or through the openings in the upper drive floor as applicable); and gathering loose tubers in the forking vicinity. Ends when the fork is placed aside.

Unavoidable delay.—Because of packing line: Begins when packing line operation is interrupted causing a delay in the supply operation. Ends when the supply operation is resumed. Because of supply operation: Begins when line supply is stopped because of conveyor belts slipping or jamming, excessive dirt buildup near conveyors, or necessary adjustment in conveyor height. Ends when the supply operation is resumed.

Cleanup.—Begins at end of storage-emptying activities as workers leave equipment storage area. Consists of gathering all dirt and debris in the storage; hand shoveling this material into wheelbarrows; and transporting the material to the dump area. Ends when the cleanup equipment is replaced in the equipment storage area.

Fluming

Fill sump.—Begins as the flume operator places hands on the valve to start the water flow to the sump. Consists of opening the valve, determining correct amount of water needed (filling is machine time whose value depends on individual system), and closing the valve. Ends when the valve is closed.

Assemble and disassemble pipe.—Begins when the flume operator stops such activities as filling sump or supplying the packing line to change the pipe system. Consists of walking to and from the pipe storage area, carrying pipe, hose, or connectors, and attaching or detaching pipe components. Ends when fluming is resumed or all pipe components are replaced in the pipe storage area.

Fill flume system.—Begins as the flume operator starts the pump. Consists of starting the pump and directing attention to the system as it fills to operating capacity (a machine time whose value depends on the individual system). Ends when the system reaches capacity.

Supply packing line (flume potatoes).—Begins as potatoes start to flow into the flumes. Consists of sluicing the tubers into the flume with the water flow, regulating the potato movement while opening bins, cleaning nearby emptied areas, and removing and replacing flume covers. Ends when potato flow into the flume is stopped. When supplying the packing line by fluming from the deep-bin storage, time for the activity "forking potatoes" as described under hand forking to conveyors is included.

Clean out sump.—Begins when fluming is stopped at end of day's activities or when storage is empty. Consists of adjusting valves and operating pump to change flow from recirculation in the flume system to discharge into the disposal system (discharge time is machine time whose value depends on the individual system), adding water with a hose to flush the sump and equipment during the discharge operation, removing by hand vines and tubers from the sump, gratings, and equipment, and resetting the valves for recirculation. Ends when the valves are reset.

Bulk Scooping

Set up and move equipment.—Begins when the bulk-scoop operator places hands on the portable bulk hopper to move it. Consists of moving the hopper from the equipment storage area to the packing line, repositioning the hopper across the alleyway, and returning the hopper to the equipment storage area. Ends when the hopper is in the required position or is returned to the storage area.

Supply packing line (power-scooping potatoes).—Begins when the bulk-scoop operator

sets the power scoop in motion for the scooping operation. Consists of directing the powered scoop into the potato pile, obtaining scoopful of potatoes, transferring potatoes to bulk hopper, dumping the load and returning to the pile, removing bin boards, and changing fuel tanks. Ends when the storage is empty.

Calculation of Equipment Costs

To determine the correct type, size, and amount of equipment required, each handling system was completely designed on the basis of storage layout and rate of supply to the packing line. Practical considerations and nominal sizes of equipment were applied to reflect commercial practice. From these data, two categories of annual equipment costs—ownership and operating—were developed.

Ownership Costs

Equipment ownership costs were independent of the hours of operation and included charges for depreciation, interest, insurance, and taxes. The cost for all items was based on 1966 new equipment prices f.o.b. Grand Forks, N. Dak. Depreciation was calculated by the straight-line method with zero salvage value. Estimated life was established using available data on the equipment, data on comparable items of equipment, and opinions of packing-house operators and equipment suppliers. Interest on the investment was set at 6 percent of the average depreciated value. Insurance was calculated at 1 percent of this value for the flumes and sump and 1.2 percent for all other equipment. Taxes were set at 2 percent of the average depreciated value. The ownership costs were charged completely to the handling operations in all systems studied.

Operating Costs

Annual equipment operating costs were dependent on the hours of operation and included charges for power, fuel, and maintenance. In the fluming operations, charges for water used were included. The costs of all items were based on 1966 rates.

Total power costs were first determined for the entire plant on the basis of monthly operating time and the electric rate schedule. Operating times were based on supplying the packing line at the required rate for 8 hours per day—20 days per month. The monthly electric rate schedule used was as follows:

	Cents per kw.-hr.
First 75 kw.-hr.	6.5
Next 425 kw.-hr.	4.5
Next 1,500 kw.-hr.	3.4
Next 5,000 kw.-hr.	2.6
Next 5,000 kw.-hr.	2.0
Excess kw.-hr.	1.75

From the total cost obtained, an average rate per kilowatt-hour was determined. This average rate was then used to calculate the cost of the power required by each handling system.

Water and sewage costs for the fluming method of handling were determined in much the same way. Monthly water requirements for each wash plant operation were developed first. With this requirement and the monthly rate schedule, total costs were obtained. The water rate schedule used was as follows:

	Cents per 1,000 gallons
First 2,000 gallons	75
Next 8,000 gallons	60
Next 20,000 gallons	50
Next 170,000 gallons	35
Over 200,000 gallons	28

The sewage rates used were $3 per month plus $0.12 per 1,000 gallons for the first 200,000 gallons of water, $0.10 per 1,000 gallons for the next 200,000 gallons of water, and $0.02 per 1,000 gallons for all in excess of 400,000 gallons of water per month. From the total cost obtained, average rates per 1,000 gallons were determined for water and for sewage. These average rates were then used to calculate the cost of water and sewage required by each fluming operation.

Fuel costs for the powered bulk scoop were established on the basis of 5 hours of operating time per tank of propane at a charge of $2.25 per tank.

Maintenance charges for the various items of equipment were applied on the basis of percent of the replacement (initial) cost per 100 hours of operation. These charges cover repair, inspection, servicing, and maintenance. The percentages used follow:

	Percent
Grating, steel plumbing, aluminum pipe and fittings, rubber coil hose, gate valves, and sump	0.5
Pump and motor	.75
Straight conveyors and uniform feed bulk hopper	1.0
Telescoping conveyors and draper-chain elevator	1.5
Powered bulk scoop	2.0

Maintenance charge for the flumes was set at $0.01 per linear foot per year. Maintenance charge for flume covers was $0.01 per board-foot per year.

Tables 15, 16, and 17 itemize the equipment costs for each handling system studied under the general heading of annual volume of potatoes handled.

TABLE 15.—*Ownership and operating costs for potato handling equipment of annual volume of 42,000 cwt., by specified type of storage and handling system*

Supply rate and amount of equipment	Initial cost	Estimated life	Ownership cost: Depreciation	Ownership cost: Interest	Ownership cost: Insurance and taxes	Ownership cost: Total	Hours of operation	Operating cost: Power	Operating cost: Water	Operating cost: Maintenance	Operating cost: Total	Total annual cost
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
BELOW-GROUND DEEP BIN—HAND FORKING TO CONVEYORS												
100 cwt. per hour:												
1 telescoping conveyor	1,375.00	15	91.67	41.25	22.00	154.92	420.00	6.89	--	86.62	93.51	248.43
3 straight conveyors	1,950.00	15	130.00	58.50	31.20	219.70	317.70	3.91	--	20.65	24.56	263.80
							184.65	2.27	--	12.00	14.27	
							68.22	.84	--	4.43	5.27	
1 elevator	850.65	15	56.71	25.52	13.61	95.84	420.00	10.34	--	53.59	63.93	159.77
1 elevator	277.13	15	18.48	8.31	4.43	31.22	420.00	--	--	17.46	17.46	48.68
3 forks	35.25	5	7.05	1.05	.56	8.66	--	--	--	--	--	8.66
1 wheelbarrow	25.00	15	1.67	.75	.40	2.82	--	--	--	--	--	2.82
1 shovel	4.00	5	.80	.12	.06	.98	--	--	--	--	--	.98
Total	--	--	--	--	--	514.14	--	--	--	--	219.00	733.14
200 cwt. per hour:												
1 telescoping conveyor	1,400.00	15	93.33	42.00	22.40	157.73	210.00	4.11	--	44.10	48.21	205.94
4 straight conveyors	2,600.00	15	173.33	78.00	41.60	292.93	137.63	1.62	--	8.95	10.57	329.98
							172.63	2.03	--	11.22	13.25	
							139.91	1.65	--	9.09	10.74	
							32.46	.38	--	2.11	2.49	
1 elevator	1,011.15	15	67.41	30.33	16.18	113.92	210.00	6.58	--	31.85	38.43	152.35
1 elevator	315.65	15	21.04	9.47	5.05	35.56	210.00	--	--	9.94	9.94	45.50
4 forks	47.00	5	9.40	1.41	.75	11.56	--	--	--	--	--	11.56
1 wheelbarrow	25.00	15	1.67	.75	.40	2.82	--	--	--	--	--	2.82
1 shovel	4.00	5	.80	.12	.06	.98	--	--	--	--	--	.98
Total	--	--	--	--	--	615.50			--		133.63	749.13
300 cwt. per hour:												
2 telescoping conveyors	2,800.00	15	186.67	84.00	44.80	315.47	140.00	2.61	--	29.40	32.01	379.49
							140.00	2.61	--	29.40	32.01	
4 straight conveyors	2,700.00	15	180.00	81.00	43.20	304.20	98.04	1.46	--	6.62	8.08	332.36
							82.34	1.24	--	5.56	6.80	
							115.49	1.72	--	7.79	9.51	
							45.85	.68	--	3.09	3.77	
1 elevator	1,225.15	15	81.68	36.75	19.60	138.03	140.00	6.26	--	25.73	31.99	170.02

1 elevator	367.01	15	24.47	11.01	5.87	41.35	140.00	--	--	7.71	7.71	49.06
5 forks	58.75	5	11.75	1.76	.94	14.45	--	--	--	--	--	14.45
2 wheelbarrows	50.00	15	3.33	1.50	.80	5.63	--	--	--	--	--	5.63
2 shovels	8.00	5	1.60	.24	.13	1.97	--	--	--	--	--	1.97
Total	--	--	--	--	--	821.10	--	--	--	-	131.88	952.98
			ABOVE-GROUND CROSS ALLEY—FLUMING									
100 cwt. per hour:												
537 ft. flumes	2,282.25	25	91.29	68.47	34.23	193.99	-	--	--	5.37	5.37	199.36
1,434 bd.-ft. flume covers	186.46	7	26.63	5.59	2.98	35.20	--	--	--	14.34	14.34	49.54
1 grating	40.00	25	1.60	1.20	.64	3.44	441.08	--	--	.88	.88	4.32
1 pump and motor	532.00	15	35.47	15.96	8.51	59.94	441.08	14.47	36.40	17.60	68.47	128.41
1 set steel plumbing	157.27	25	6.29	4.72	2.52	13.53	441.08	--	--	3.47	3.47	17.00
106 ft. pipe and fittings	180.88	25	7.24	5.43	2.89	15.56	424.20	--	--	3.84	3.84	19.40
30 ft. rubber coil hose	139.20	10	13.92	4.18	2.23	20.33	424.20	--	--	2.95	2.95	23.28
2 gate valves	88.00	15	5.87	2.64	1.41	9.92	441.08	--	--	1.94	1.94	11.86
157 ft.^{2} sump	314.00	25	12.56	9.42	4.71	26.69	441.08	-	--	6.92	6.92	33.61
1 elevator	594.41	15	39.63	17.83	9.51	66.97	420.00	5.17	--	37.45	42.62	109.59
Total	--	--	--	--	--	445.57	-	--	--	-	150.80	596.37
200 cwt. per hour:												
537 ft. flumes	2,282.25	25	91.29	68.47	34.23	193.99	-	--	--	5.37	5.37	199.36
1,434 bd.-ft. flume covers	186.42	7	26.63	5.59	2.98	35.20	--	--	-	14.34	14.34	49.54
1 grating	40.00	25	1.60	1.20	.64	3.44	224.53	--	--	.45	.45	3.89
1 pump and motor	765.00	15	51.00	22.95	12.24	86.19	224.53	17.58	29.27	12.88	59.73	145.92
1 set steel plumbing	205.12	25	8.20	6.15	3.28	17.63	224.53	--	--	2.30	2.30	19.93
106 ft. pipe and fittings	229.20	25	9.17	6.88	3.67	19.72	212.12	--	--	2.43	2.43	22.15
30 ft. rubber coil hose	154.50	10	15.45	4.64	2.47	22.56	212.12	--	--	1.64	1.64	24.20
2 gate valves	109.00	15	7.27	3.27	1.74	12.28	224.53	--	--	1.22	1.22	13.50
157 ft.^{2} sump	314.00	25	12.56	9.42	4.71	26.69	224.53	--	--	3.53	3.53	30.22
1 elevator	823.70	15	54.91	24.71	13.18	92 80	210.00	3.29	--	25.95	29.24	122.04
Total	--	--	--	-		510.50	--	--	--		120.25	630.75
300 cwt. per hour:												
537 ft. flumes	2,282.25	25	91.29	68.47	34.23	193.99	--	--	--	5.37	5.37	199.36
1,434 bd.-ft. flume covers	186.42	7	26.63	5.59	2.98	35.20	--	--	--	14.34	14.34	49.54
1 grating	40.00	25	1.60	1.20	.64	3.44	149.61	--	--	.30	.30	3.74
1 pump and motor	858.00	15	57.20	25.74	13.73	96.67	149.61	16.73	26.38	9.63	52.74	149.41
1 set steel plumbing	249.32	25	9.97	7.48	3.99	21.44	149.61	--	--	1.87	1.87	23.31
106 ft. pipe and fittings	290.58	25	11.62	8.72	4.65	24.99	141.40	--	--	2.05	2.05	27.04
30 ft. rubber coil hose	233.40	10	23.34	7.00	3.73	34.07	141.40	--	--	1.65	1.65	35.72
2 gate valves	131.00	15	8.73	3.93	2.10	14.76	149.61	--	--	.98	.98	15.74
178 ft.^{2} sump	356.00	25	14.24	10.68	5.34	30.26	149.61	-	--	2.66	2.66	32.92
1 elevator	944.16	15	62.94	28.32	15.11	106.37	140.00	4.18		19.83	24.01	130.38
Total	--	--	--	--		561.19	--	--	--		105.97	667.16

TABLE 15.—*Ownership and operating costs for potato handling equipment of annual volume of 42,000 cwt., by specified type of storage and handling system*—Continued

Supply rate and amount of equipment	Initial cost	Estimated life	Ownership cost: Depreciation	Ownership cost: Interest	Ownership cost: Insurance and taxes	Ownership cost: Total	Hours of operation	Operating cost: Power	Operating cost: Water	Operating cost: Maintenance	Operating cost: Total	Total annual cost
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
ABOVE-GROUND DOOR-PER-BIN—FLUMING												
100 cwt. per hour:												
571.5 ft. flumes	2,428.88	25	97.16	72.87	36.43	206.46	--	--	--	5.72	5.72	212.18
1,526 bd.-ft. flume covers	198.38	7	28.34	5.95	3.17	37.46	--	--	--	15.26	15.26	52.72
1 grating	40.00	25	1.60	1.20	.64	3.44	445.01	--	--	.89	.89	4.33
1 pump and motor	532.00	15	35.47	15.96	8.51	59.94	445.01	14.60	38.56	17.75	70.91	130.85
1 set steel plumbing	156.97	25	6.28	4.71	2.51	13.50	445.01	--	--	3.49	3.49	16.99
149 ft. pipe and fittings	240.70	25	9.63	7.22	3.85	20.70	425.90	--	--	5.12	5.12	25.82
30 ft. rubber coil hose	139.20	10	13.92	4.18	2.23	20.33	425.90	--	--	2.96	2.96	23.29
2 gate valves	88.00	15	5.87	2.64	1.41	9.92	445.01	--	--	1.96	1.96	11.88
214 ft.^{2} sump	428.00	25	17.12	12.84	6.42	36.38	445.01	--	--	9.52	9.52	45.90
1 elevator	604.55	15	40.30	18.14	9.67	68.11	420.00	5.17	--	38.09	43.26	111.37
Total	--	--	--	--	--	476.24	--	--	--		159.09	634.33
200 cwt. per hour:												
571.5 ft. flumes	2,428.88	25	97.16	72.87	36.43	206.46	--	--	--	5.72	5.72	212.18
1,526 bd.-ft. flume covers	198.38	7	28.34	5.95	3.17	37.46	--	--	--	15.26	15.26	52.72
1 grating	40.00	25	1.60	1.20	.64	3.44	225.96	--	--	.45	.45	3.89
1 pump and motor	765.00	15	51.00	22.95	12.24	86.19	225.96	17.69	30.70	12.96	61.35	147.54
1 set steel plumbing	204.52	25	8.18	6.14	3.27	17.59	225.96		--	2.31	2.31	19.90
149-ft. pipe and fittings	305.51	25	12.22	9.17	4.89	26.28	212.98	--	--	3.25	3.25	29.53
30 ft. rubber coil hose	154.50	10	15.45	4.62	2.47	22.54	212.98	--	--	1.64	1.64	24.18
2 gate valves	109.00	15	7.27	3.27	1.74	12.28	225.96	--	--	1.23	1.23	13.51
214 ft.^{2} sump	428.00	25	17.12	12.84	6.42	36.38	225.96		--	4.83	4.83	41.21
1 elevator	839.95	15	56.00	25.00	13.44	94.64	210.00	3.29	--	26.46	29.75	124.39
Total	--	--	--	--	--	543.26	--	--	--		125.79	669.05

300 cwt. per hour:												
571.5 ft. flumes	2,428.88	25	97.16	72.87	36.43	206.46	--	--	--	5.72	5.72	212.18
1,526 bd.-ft. flume covers	198.38	7	28.34	5.95	3.17	37.46	--	--	--	15.26	15.26	52.72
1 grating	40.00	25	1.60	1.20	.64	3.44	150.37	--	--	.30	.30	3.74
1 pump and motor	858.00	15	57.20	25.74	13.73	96.67	150.37	16.82	27.31	9.68	53.81	150.48
1 set steel and plumbing	248.72	25	9.95	7.46	3.98	21.39	150.37	--	--	1.87	1.87	23.26
149 ft. pipe and fittings	385.79	25	15.43	11.57	6.17	33.17	141.97	--	--	2.74	2.74	35.91
30 ft. rubber coil hose	233.40	10	23.34	7.00	3.73	34.07	141.97	--	--	1.66	1.66	35.73
2 gate valves	131.00	15	8.73	3.93	2.10	14.76	150.37	--	--	.98	.98	15.74
225 ft.^{2} sump	450.00	25	18.00	13.50	6.75	38.25	150.37	--	--	3.38	3.38	41.63
1 elevator	964 07	15	64.27	28.92	15.43	108.62	140.00	4.18	--	20.24	24.42	133.04
Total	--	--	--	--	--	594.29	--	--	--	--	110.14	704.43
			BELOW-GROUND DEEP-BIN—FLUMING									
100 cwt. per hour:												
547 ft. flumes	1,899.75	25	75.99	56.99	28.50	161.48	--	--	--	5.47	5.47	166.95
1,460 bd.-ft. flume covers	189.90	7	27.11	5.69	3.04	35.84	--	--	--	14.60	14.60	50.44
1 grating	40.00	25	1.60	1.20	.64	3.44	440.73	--	--	.88	.88	4.32
1 pump and motor	532.00	15	35.47	15.96	8.51	59.94	440.73	14.46	34.41	17.59	66.46	126.40
1 set steel plumbing	157.47	25	6.30	4.72	2.52	13.54	440.73	--	--	3.47	3.47	17.01
71 ft. pipe and fittings	147.11	25	5.88	4.41	2.35	12.64	423.03	--	--	3.11	3.11	15.75
30 ft. rubber coil hose	139.20	10	13.92	4.18	2.23	20.33	423.03	--	--	2.94	2.94	23.27
2 gate valves	88.00	15	5.87	2.64	1.40	9.91	440.73	--	--	1.94	1.94	11.85
169 ft.^{2} sump	338.00	25	13.52	10.14	5.07	28.73	440.73	--	--	7.75	7.75	36.48
1 elevator	863.49	15	57.57	25.90	13.82	97.29	420.00	10.34	--	54.40	64.74	162.03
1 elevator	277.13	15	18.48	8.31	4.43	31.22	420.00	--	--	17.46	17.46	48.68
Total	--	--	--	--	--	474.36	--	--	--	--	188.82	663.18
200 cwt. per hour:												
547 ft. flumes	1,899.75	25	75.99	56.99	28.50	161.48	--	--	--	5.47	5.47	166.95
1,460 bd.-ft. flume covers	189.80	7	27.11	5.69	3.04	35.84	--	--	--	14.60	14.60	50.44
1 grating	40.00	25	1.60	1.20	.64	3.44	224.14	--	--	.45	.45	3.89
1 pump and motor	765.00	15	51.00	22.95	12.24	86.19	224.14	17.55	28.82	12.86	59.23	145.42
1 set steel plumbing	205.52	25	8.22	6.17	3.29	17.68	224.14	--	--	2.30	2.30	19.98
71 ft. pipe and fittings	184.89	25	7.40	5.55	2.96	15.91	211.53	--	--	1.95	1.95	17.86
30 ft. rubber coil hose	154.50	10	15.45	4.64	2.47	22.56	211.53	--	--	1.63	1.63	24.19
2 gate valves	109.00	15	7.27	3.27	1.74	12.28	224.14	--	--	1.22	1.22	13.50
169 ft.^{2} sump	338.00	25	13.52	10.14	5.07	28.73	224.14	--	--	3.79	3.79	32.52
1 elevator	1,027.20	15	68.48	30.82	16.44	115.74	210.00	6.58	--	32.36	38.94	154.68
1 elevator	315 65	15	21.04	9.47	5.05	35.56	210.00	--	--	9.94	9.94	45.50
Total	--	--	--	--	--	535.41	--	--	--		139.52	674.93

TABLE 15.—*Ownership and operating costs for potato handling equipment of annual volume of 42,000 cwt., by specified type of storage and handling system*—Continued

Supply rate and amount of equipment	Initial cost	Estimated life	Ownership cost: Depreciation	Ownership cost: Interest	Ownership cost: Insurance and taxes	Ownership cost: Total	Hours of operation	Operating cost: Power	Operating cost: Water	Operating cost: Maintenance	Operating cost: Total	Total annual cost
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
BELOW GROUND DEEP BIN—FLUMING—Continued												
300 cwt. per hour:												
547 ft. flumes	1,899.75	25	75.99	56.99	28.50	161.48	--	--	--	5.47	5.47	166.95
1,460 bd.-ft. flume covers	189.80	7	27.11	5.69	3.04	35.84	--	--	--	14.60	14.60	50.44
1 grating	40.00	25	1.60	1.20	.64	3.44	149.20	--	--	.30	.30	3.74
1 pump and motor	858.00	15	57.20	25.74	13.73	96.67	149.20	16.69	25.53	9.60	51.82	148.49
1 set steel plumbing	249.72	25	9.99	7.49	4.00	21.48	149.20	--	--	1.86	1.86	23.34
71 ft. pipe and fittings	233.63	25	9.35	7.01	3.74	20.10	141.01	--	--	1.65	1.65	21.75
30 ft. rubber coil hose	233.40	10	23.34	7.00	3.73	34.07	141.01	--	--	1.64	1.64	35.71
2 gate valves	131.00	15	8.73	3.39	2.10	14.22	149.20	--	--	.98	.98	15.20
169 ft.^{2} sump	338.00	25	13.52	10.14	5.07	28.73	149.20	--	--	2.52	2.52	31.25
1 elevator	1,245.48	15	83.03	37.36	19.93	140.32	140.00	6.26	--	26.15	32.41	172.73
1 elevator	367.01	15	24.47	11.01	5.87	41.35	140.00	--	--	7.71	7.71	49.06
Total	--	--	--	--	--	597.70	--	--	--	--	120.96	718.66
ABOVE-GROUND CROSS ALLEY—BULK SCOOPING												
100 cwt. per hour:												
1 powered bulk scoop	4,280.00	15	285.33	128.40	68.48	482.21	57.75	--	25.99	49.43	75.42	557.63
1 uniform feed hopper	835.00	15	55.67	25.05	13.36	94.08	420.00	3.45	--	35.07	38.52	132.60
1 elevator	277.13	15	18.48	8.31	4.43	31.22	420.00	--	--	17.45	17.46	48.68
2 LP gas bottles	136.00	20	6.80	4.08	2.18	13.06	--	--	--	--		13.06
Total						620.57		--	--		131.40	751.97
200 cwt. per hour:												
1 powered bulk scoop	4,280.00	15	285.33	128.40	68.48	482.21	57.75	--	25.99	49.43	75.42	557.63
1 uniform feed hopper	835.00	15	55.67	25.05	13.36	94.08	210.00	2.47	--	17.54	20.01	114.09
1 elevator	315.65	15	21.04	9.47	5.05	35.56	210.00	--	--	9.94	9.94	45.50
2 LP gas bottles	136.00	20	6.80	4.08	2.18	13.06	--	--	--	--		13.06
Total	--	--	--	--		624.91	--	--	--	--	105.37	730.28
300 cwt. per hour:												
1 powered bulk scoop	4,280.00	15	285.33	128.40	68.48	482.21	57.75	--	25.99	49.43	75.42	557.63
1 uniform feed hopper	835.00	15	55.67	25.05	13.36	94.08	140.00	2.10	--	11.69	13.79	107.87
1 elevator	367.01	15	24.47	11.01	5.87	41.35	140.00	--	--	7.71	7.71	49.06
2 LP gas bottles	136.00	20	6.80	4.08	2.18	13.06	--	--	--	--	--	13.06
Total	--	--	--	--	--	630.70		--			96.92	727.62

TABLE 16.—*Ownership and operating costs for potato handling equipment of annual volume of 60,000 cwt., by specified type of storage and handling system*

Supply rate and amount of equipment	Initial cost	Estimated life	Ownership cost: Depreciation	Ownership cost: Interest	Ownership cost: Insurance and taxes	Ownership cost: Total	Hours of operation	Operating cost: Power	Operating cost: Water	Operating cost: Maintenance	Operating cost: Total	Total annual cost
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
BELOW-GROUND DEEP BIN—HAND FORKING TO CONVEYORS												
100 cwt. per hour:												
1 telescoping conveyor	1,375.00	15	91.67	41.25	22.00	154.92	600.00	9.84	--	123.75	133.59	288.51
4 straight conveyors	2,640.00	15	176.00	79.20	42.24	297.44	498.96	6.14	--	32.43	38.57	393.63
							360.48	4.44	--	23.43	27.87	
							241.80	2.98	--	15.72	18.70	
							135.60	1.69	--	9.36	11.05	
1 elevator	850.65	15	56.71	25.52	13.61	95.84	600.00	14.76	--	76.56	91.32	187.16
1 elevator	277.13	15	18.48	8.31	4.43	31.22	600.00	--	--	24.94	24.94	56.16
3 forks	35.25	5	7.05	1.06	.56	8.67	--	--	--	--	--	8.67
1 wheelbarrow	25.00	15	1.67	.75	.40	2.82	--	--	--	--	--	2.82
1 shovel	4.00	5	.80	.12	.06	.98	--	--	--	--	--	.98
Total	--	--	--	--	--	591.89	--	--	--	--	346.04	937.93
200 cwt. per hour:												
1 telescoping conveyor	1,400.00	15	93.33	42.00	22.40	157.73	300.00	5.59	--	63.00	68.59	226.32
5 straight conveyors	3,315.00	15	221.00	99.45	53.04	373.49	197.15	2.21	--	12.81	15.02	441.63
							189.05	2.11	--	12.29	14.40	
							220.28	2.46	--	14.32	16.78	
							172.58	1.93	--	11.22	13.15	
							101.70	1.52	--	7.27	8.79	
1 elevator	1,011.15	15	67.41	30.33	16.18	113.92	300.00	8.95	--	45.50	54.45	168.37
1 elevator	315.65	15	21.04	9.47	5.05	35.56	300.00	--	--	14.20	14.20	49.76
4 forks	47.00	5	9.40	1.41	.75	11.56	--	--	--	--	--	11.56
1 wheelbarrow	25.00	15	1.67	.75	.40	2.82	--	--	--	--	--	2.82
1 shovel	4.00	5	.80	.12	.06	.98	--	--	--	--	--	.98
Total	--	--	--	--	--	696.06	--	--	--	--	205.38	901.44

TABLE 16.—*Ownership and operating costs for potato handling equipment of annual volume of 60,000 cwt., by specified type of storage and handling system*—Continued

Supply rate and amount of equipment	Initial cost	Estimated life	Ownership cost: Depreciation	Ownership cost: Interest	Ownership cost: Insurance and taxes	Ownership cost: Total	Hours of operation	Operating cost: Power	Operating cost: Water	Operating cost: Maintenance	Operating cost: Total	Total annual cost
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
BELOW-GROUND DEEP BIN—HAND FORKING TO CONVEYORS—Continued												
300 cwt. per hour:												
2 telescoping conveyors	2,800.00	15	186.67	84.00	44.80	315.47	200.00	3.91	-	42.00	45.91	407.29
							200.00	3.91	--	42.00	45.91	
6 straight conveyors	4,090.00	15	272.67	122.70	65.44	460.81	165.00	2.58	--	11.14	13.72	527.78
							159.84	2.50	--	10.79	13.29	
							151.08	2.37	--	10.20	12.57	
							151.84	2.38	--	10.25	12.63	
							41.80	.65	--	2.82	3.47	
							129.48	2.03	--	9.26	11.29	
1 elevator	1,225.15	15	81.68	36.75	19.60	138.03	200.00	9.40	--	36.75	46.15	184.18
1 elevator	367.01	15	24.47	11.01	5.87	41.35	200.00		--	11.01	11.01	52.36
5 forks	58.75	5	11.75	1.76	.94	14.45	-	--	--	--	--	14.45
2 wheelbarrows	50.00	15	3.33	1.50	.80	5.63	-	--	--	--	--	5.63
2 shovels	8.00	5	1.60	.24	.13	1.97	--	--	--	--	-	1.97
Total	--	--	--	--	--	977.71	--	--	--	--	215.95	1,193.66
ABOVE-GROUND CROSS ALLEY—FLUMING												
100 cwt. per hour:												
742 ft. flumes	3,153.50	25	126.14	94.60	47.30	268.04	-	-	--	7.42	7.42	275.46
1,981 bd.-ft. flume covers	257.53	7	36.79	7.73	4.12	48.64		-	-	19.81	19.81	68.45
1 grating	40.00	25	1.60	1.20	.64	3.44	633.44	-	-	1.27	1.27	4.71
1 pump and motor	532.00	15	35.47	15.96	8.51	59.94	633.44	20.78	52.64	25.27	98.69	158.63
1 set steel plumbing	157.12	25	6.28	4.71	2.51	13.50	633.44	--	--	4.98	4.98	18.48
129 ft. pipe and fittings	206.62	25	8.26	6.19	3.31	17.76	607.68	--	--	6.28	6.28	24.04
30 ft. rubber coil hose	139.00	10	13.92	4.18	2.23	20.33	607.68	--	--	4.23	4.23	24.56
2 gate valves	88.00	15	5.87	2.64	1.41	9.92	633.44	--	--	2.79	2.79	12.71
186 ft.^{2} sump	372.00	25	14.88	11.16	5.58	31.62	633.44	-	--	11.78	11.78	43.40
1 elevator	604.55	15	40.30	18.14	9.67	68.11	600.00	7.38	--	54.41	61.79	129.90
Total	-	--	--	--	--	541.30	--	--	--	--	219.04	760.34
200 cwt. per hour:												
742 ft. flumes	3,153.50	25	126.14	94.60	47.30	268.04	--	--	--	7.42	7.42	275.46
1,981 bd.-ft. flume covers	257.53	7	36.79	7.73	4.12	48.64	--	--	--	19.81	19.81	68.45
1 grating	40.00	25	1.60	1.20	.64	3.44	321.99	--	--	.64	.64	4.08
1 pump and motor	765.00	15	51.00	22.95	12.24	86.19	321.99	24.01	40.71	18.47	83.19	169.38
1 set steel plumbing	204.82	25	8.19	6.14	3.28	17.61	321.99	--	--	3.30	3.30	20.91

129 ft. pipe and fittings	262.55	25	10.50	7.88	4.20	22.58	303.84	--	--	3.99	3.99	26.57
30 ft. rubber coil hose	154.50	10	15.45	4.64	2.47	22.56	303.84	--	--	2.35	2.35	24.91
2 gate valves	109.00	15	7.27	3.27	1.74	12.28	321.99	--	--	1.75	1.75	14.03
186 ft.^{2} sump	372.00	25	14.88	11.16	5.58	31.62	321.99	--	--	5.99	5.99	37.61
1 elevator	839.95	15	56.00	25.20	13.44	94.64	300.00	4.47	--	37.80	42.27	136.91
Total	--	--	--	--	--	607.60	--	--	--	--	170.71	778.31
300 cwt. per hour:												
742 ft. flumes	3,153.50	25	126.14	94.60	47.30	268.04	--	--	--	7.42	7.42	275.46
1,981 bd.-ft. flume covers	257.33	7	36.79	7.73	4.12	48.64	--	--	--	19.81	19.81	68.45
1 grating	40.00	25	1.60	1.20	.64	3.44	214.37	--	--	.43	.43	3.87
1 pump and motor	858.00	15	57.20	25.74	13.73	96.67	214.37	25.18	40.31	13.79	79.28	175.95
1 set steel plumbing	249.02	25	9.96	7.47	3.98	21.41	214.37	--	--	2.67	2.67	24.08
129 ft. pipe and fittings	332.89	25	13.32	9.99	5.33	28.64	202.56	--	--	3.37	3.37	32.01
30 ft. rubber coil hose	233.40	10	23.34	7.00	3.73	34.07	202.56	--	--	2.36	2.36	36.43
2 gate valves	131.00	15	8.73	3.93	2.10	14.76	214.37	--	--	1.40	1.40	16.16
195 ft.^{2} sump	390.00	25	15.60	11.70	5.85	33.15	214.37	--	--	4.18	4.18	37.33
1 elevator	964.07	15	64.27	28.92	15.43	108.62	200.00	6.26	--	28.92	35.18	143.80
Total	--	--	--	--	--	657.44	--	--	--	--	156.10	813.54
ABOVE-GROUND DOOR-PER-BIN—FLUMING												
100 cwt. per hour:												
814.5 ft. flumes	3,491.62	25	139.66	104.75	52.37	296.78	--	--	--	8.14	8.14	304.92
2,175 bd.-ft flume covers	282.75	7	40.39	8.48	4.52	53.39	--	--	--	21.75	21.75	75.14
1 grating	40.00	25	1.60	1.20	.64	3.44	640.30	--	--	1.28	1.28	4.72
1 pump and motor	532.00	15	35.47	15.96	8.51	59.94	640.30	21.01	57.23	25.55	103.79	163.73
1 set steel plumbing	156.67	25	6.27	4.70	2.50	13.47	640.30	--	--	5.01	5.01	18.48
197 ft. pipe and fittings	303.86	25	12.15	9.12	4.86	26.13	610.50	--	--	9.27	9.27	35.40
30 ft. rubber coil hose	139.20	10	13.92	4.18	2.23	20.33	610.50	--	--	4.25	4.25	24.58
2 gate valves	88.00	15	5.87	2.64	1.40	9.91	640.30	--	--	2.82	2.82	12.73
270 ft.^{2} sump	540.00	25	21.60	16.20	8.10	45.90	640.30	--	--	17.29	17.29	63.19
1 elevator	615.25	15	41.02	18.46	9.84	69.32	600.00	7.38	--	55.37	62.75	132.07
Total	--	--	--	--	--	598.61	--	--	--	--	236.35	834.96
200 cwt. per hour:												
814.5 ft. flumes	3,491.62	25	139.66	104.75	52.37	296.78	--	--	--	8.14	8.14	304.92
2,175 bd.-ft. flume covers	282.75	7	40.39	8.48	4.52	53.39	--	--	--	21.75	21.75	75.14
1 grating	40.00	25	1.60	1.20	.64	3.44	324.42	--	--	.65	.65	4.09
1 pump and motor	765.00	15	51.00	22.95	12.24	86.19	324.42	24.19	42.77	18.61	85.57	171.76
1 set steel plumbing	203.91	25	8.16	6.12	3.26	17.54	324.42	--	--	3.31	3.31	20.85
197 ft. pipe and fittings	386.31	25	15.45	11.59	6.18	33.22	305.25	--	--	5.90	5.90	39.12
30 ft. rubber coil hose	154.50	10	15.45	4.64	2.47	22.56	305.25	--	--	2.36	2.36	24.92
2 gate valves	109.00	15	7.27	3.27	1.74	12.28	324.42	--	--	1.77	1.77	14.05
270 ft.^{2} sump	540.00	25	21.60	16.20	8.10	45.90	324.42	--	--	8.76	8.76	54.66
1 elevator	856.00	15	57.07	25.68	13.70	96.45	300.00	4.47	--	38.52	42.99	139.44
Total	--	--	--	--	--	667.75	--	--	--	--	181.20	848.95

TABLE 16.—*Ownership and operating costs for potato handling equipment of annual volume of 60,000 cwt., by specified type of storage and handling system*—Continued

Supply rate and amount of equipment	Initial cost	Estimated life	Ownership cost: Depreciation	Ownership cost: Interest	Ownership cost: Insurance and taxes	Ownership cost: Total	Hours of operation	Operating cost: Power	Operating cost: Water	Operating cost: Maintenance	Operating cost: Total	Total annual cost
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
ABOVE-GROUND DOOR-PER-BIN—FLUMING—Continued												
300 cwt. per hour:												
814.5 ft. flumes	3,491.62	25	139.66	104.75	52.37	296.78	--	--	--	8.14	8.14	304.92
2,175 bd.-ft. flume covers	282.75	7	40.39	8.48	4.52	53.39	--	--	--	21.75	21.75	75.14
1 grating	40.00	25	1.60	1.20	.64	3.44	215.70	--	--	.43	.43	3.87
1 pump and motor	858.00	15	57.20	25.74	13.73	96.67	215.70	25.33	42.20	13.88	81.41	178.08
1 set steel plumbing	248.11	25	9.92	7.44	3.97	21.33	215.70	--	--	2.68	2.68	24.01
197 ft. pipe and fittings	487.10	25	19.48	14.61	7.79	41.88	203.50	--	--	4.96	4.96	46.84
30 ft. rubber coil hose	233.40	10	23.34	7.00	3.73	34.07	203.50	--	--	2.37	2.37	36.44
2 gate valves	131.00	15	8.73	3.93	2.10	14.76	215.70	--	--	1.41	1.41	16.17
272 ft.^{2} sump	544.00	25	21.76	16.32	8.16	46.24	215.70	--	--	5.87	5.87	52.11
1 elevator	984 40	15	65.63	29.53	15.75	110.91	200.00	6.26	--	29.53	35.79	146.70
Total	--	--	--	--	--	719.47	--	--	--	--	164.81	884.28
BELOW-GROUND DEEP BIN—FLUMING												
100 cwt. per hour:												
787 ft. flumes	3,344.75	25	133.79	100.34	50.17	284.30	--	--	--	7.87	7.87	292.17
2,101 bd.-ft. flume covers	273.13	7	39.02	8.19	4.37	51.58	--	--	--	21.01	21.01	72.59
1 grating	40.00	25	1.60	1.20	.64	3.44	630.77	--	--	1.26	1.26	4.70
1 pump and motor	532.00	15	35.47	15.96	8.51	59.94	630.77	20.70	50.64	25.17	96.51	156.45
1 set steel plumbing	157.32	25	6.29	4.72	2.52	13.53	630.77	--	--	4.96	4.96	18.49
97 ft. pipe and fittings	185.21	25	7.40	5.56	2.96	15.92	605.82	--	--	5.61	5.61	21.53
30 ft. rubber coil hose	139.20	10	13.92	4.18	2.23	20.33	605.82	--	--	4.22	4.22	24.55
2 gate valves	88.00	15	5.87	2.64	1.40	9.91	630.77	--	--	2.77	2.77	12.68
169 ft.^{2} sump	338.00	25	13.52	10.14	5.07	28.73	630.77	--	--	10.66	10.66	39.39
1 elevator	863.49	15	57.57	25.90	13.82	97.29	600.00	14.76	--	77.71	92.47	189.76
1 elevator	277.13	15	18.48	8.31	4.43	31.22	600.00	--	--	24.94	24.94	56.16
Total	--	--	--	--	--	616.19	--	--	--	--	272.28	888.47
200 cwt. per hour:												
787 ft. flumes	3,344.75	25	133.79	100.34	50.17	284.30	--	--	--	7.87	7.87	292.17
2,101 bd.-ft. flume covers	273.13	7	39.02	8.19	4.37	51.58	--	--	--	21.01	21.01	72.59
1 grating	40.00	25	1.60	1.20	.64	3.44	320.85	--	--	.64	.64	4.08
1 pump and motor	765.00	15	51.00	22.95	12.24	86.19	320.85	23.93	39.74	18.41	82.08	168.27
1 set steel plumbing	205.57	25	8.22	6.17	3.29	17.68	320.85	--	--	3.30	3.30	20.98
97 ft. pipe and fittings	233.33	25	9.33	7.00	3.73	20.06	302.91	--	--	3.53	3.53	23.59

30 ft. rubber coil hose	154.50	10	15.45	4.64	2.47	22.56	302.91	--	--	2.34	2.34	24.90
2 gate valves	109.00	15	7.27	3.27	1.74	12.28	320.85	--	--	1.75	1.75	14.03
169 ft.^{2} sump	338.00	25	13.52	10.14	5.07	28.73	320.85	--	--	5.42	5.42	34.15
1 elevator	1,027.20	15	68.48	30.82	16.44	115.74	300.00	8.95	--	46.22	55.17	170.91
1 elevator	315.65	15	21.04	9.47	5.05	35.56	300.00	--	--	14.20	14.20	49.76
Total	--	--	--	--	--	678.12	--	--	--	--	197.31	875.43
200 cwt. per hour:												
787 ft. flumes	3,344.75	25	133.79	100.34	50.17	284.30	--	--	--	7.87	7.87	292.17
2,101 bd.-ft. flume covers	273.13	7	39.02	8.19	4.37	51.58	--	--	--	21.01	21.01	72.59
1 grating	40.00	25	1.60	1.20	.64	3.44	213.63	--	--	.43	.43	3.87
1 pump and motor	858.00	15	57.20	25.74	13.73	96.67	213.63	25.09	39.24	13.75	78.08	174.75
1 set steel plumbing	249.42	25	9.98	7.48	3.99	21.45	213.63	--	--	2.66	2.66	24.11
97 ft. pipe and fittings	293.85	25	11.75	8.82	4.70	25.27	201.94	--	--	2.97	2.97	28.24
30 ft. rubber coil hose	233.40	10	23.34	7.00	3.73	34.07	201.94	--	--	2.36	2.36	36.43
2 gate valves	131.00	15	8.73	3.93	2.10	14.76	213.63	--	--	1.40	1.40	16.16
169 ft.^{2} sump	338.00	25	13.52	10.14	5.07	28.73	213.63	--	--	3.61	3.61	32.34
1 elevator	1,245.48	15	83.03	37.36	19.93	140.32	200.00	9.40	--	37.36	46.76	187.08
1 elevator	367.01	15	24.47	11.01	5.87	41.35	200.00	--	--	11.01	11.01	52.36
Total	--	--	--	--	--	741.94	--	--	--	--	178.16	920.10
			ABOVE-GROUND CROSS ALLEY—BULK SCOOPING									
100 cwt. per hour:												
1 powered bulk scoop	4,280.00	15	285.33	128.40	68.48	482.21	87.43	--	39.34	74.84	114.18	596.39
1 uniform feed hopper	835.00	15	55.67	25.05	13.36	94.08	600.00	4.92	--	50.10	55.02	149.10
1 elevator	277.13	15	18.48	8.31	4.43	31.22	600.00	--	--	24.94	24.94	56.16
2 LP gas bottles	136.00	20	6.80	4.08	2.18	13.06	--	--	--	--		13.06
Total	--	--	--	--	--	620.57	--	--	--	--	194.14	814.71
200 cwt. per hour:												
1 powered bulk scoop	4,280.00	15	285.33	128.40	68.48	482.21	87.43	-	39.34	74.84	114.18	596.39
1 uniform feed hopper	835.00	15	55.67	25.05	13.36	94.08	300.00	3.36	--	25.05	28.41	122.49
1 elevator	315.65	15	21.04	9.47	5.05	35.56	300.00	-	--	14.20	14.20	49.76
2 LP gas bottles	136.00	20	6.80	4.08	2.18	13.06	--	--	--	--	--	13.06
Total	--	--	--	--	--	624.91	--	--	--	--	156.79	781.70
300 cwt. per hour:												
1 powered bulk scoop	4,280.00	15	285.33	128.40	68.48	482.21	87.43	-	39.34	74.84	114.18	596.39
1 uniform feed hooper	835.00	15	55.67	25.05	13.36	94.08	200.00	3.13	--	16.70	19.83	113.91
1 elevator	367.01	15	24.47	11.01	5.87	41.35	200.00	--	--	11.01	11.01	52.36
2 LP gas bottles	136.00	20	6.80	4.08	2.18	13.06	--	--	--	--	--	13.06
Total	--	--	--	--	--	630.70	--	--	--	--	145.02	775.72

TABLE 17.—*Ownership and operating costs for potato handling equipment of annual volume of 120,000 cwt., by specified type of storage and handling system*

Supply rate and amount of equipment	Initial cost	Estimated life	Ownership cost: Depreciation	Ownership cost: Interest	Ownership cost: Insurance and taxes	Ownership cost: Total	Hours of operation	Operating cost: Power	Operating cost: Water	Operating cost: Maintenance	Operating cost: Total	Total annual cost
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
BELOW GROUND DEEP BIN—HAND FORKING TO CONVEYORS												
100 cwt. per hour:												
1 telescoping conveyor	1,375.00	15	91.67	41.25	22.00	154.92	1,200.00	19.69	--	247.50	267.19	422.11
7 straight conveyors	4,710.00	15	314.00	141.30	75.36	530.66	997.92	12.31	--	64.86	77.17	869.04
							720.96	8.87	--	46.86	55.73	
							483.60	5.95	--	31.43	37.38	
							271.20	3.35	--	18.71	22.06	
							600.00	7.28	--	41.40	48.68	
							600.00	7.28	--	41.40	48.68	
							600.00	7.28	--	41.40	48.68	
1 elevator	850.65	15	56.71	25.52	13.61	95.84	1,200.00	29.53	--	153.12	182.65	278.49
1 elevator	277.13	15	18.48	8.31	4.43	31.22	1,200.00	--	--	49.88	49.88	81.10
3 forks	35.25	5	7.05	1.06	.56	8.67	--	--	--	--	--	8.67
1 wheelbarrow	25.00	15	1.67	.75	.40	2.82	--	--	--	--	--	2.82
1 shovel	4.00	5	.80	.12	.06	.98	--	--	--	--	--	.98
Total	--	--	--	--	--	825.11	--	--	--	--	838.10	1,663.21
200 cwt. per hour:												
1 telescoping conveyor	1,400.00	15	93.33	42.00	22.40	157.73	600.00	11.19	--	126.00	137.19	294.92
8 straight conveyors	5,460.00	15	364.00	163.80	87.36	615.16	394.30	4.41	--	25.63	30.04	829.21
							378.10	4.23	--	24.58	28.81	
							440.56	4.93	--	28.64	33.57	
							345.16	3.86	--	22.44	26.30	
							203.40	3.03	--	14.54	17.57	
							300.00	4.47	--	21.45	25.92	
							300.00	4.47	--	21.45	25.92	
							300.00	4.47	--	21.45	25.92	
1 elevator	1,011.15	15	67.41	30.33	16.18	113.92	600.00	17.90	--	91.00	108.90	222.82
1 elevator	315.65	15	21.04	9.47	5.05	35.56	600.00	--	--	28.41	28.41	63.97
4 forks	47.00	5	9.40	1.41	.75	11.56	--	--	--	--	--	11.56
1 wheelbarrow	25.00	15	1.67	.75	.40	2.82	--	--	--	--	--	2.82
1 shovel	4.00	5	.80	.12	.06	.98	--	--	--	--	--	.98
Total	--	--	--	--	--	937.73	--	--	--	--	488.55	1,426.28

300 cwt. per hour:												
2 telescoping conveyors	2,800.00	15	186.67	84.00	44.80	315.47	400.00	7.46	--	84.00	91.46	498.39
							400.00	7.46	--	84.00	91.46	
							330.00	4.92	--	22.28	27.20	
							319.68	4.77	--	21.58	26.35	
							302.16	4.51	--	20.40	24.91	
							303.68	4.53	--	20.50	25.03	
9 straight conveyors	6,135.00	15	409.00	184.05	98.16	691.21	83.60	1.25	--	5.64	6.89	875.81
							258.96	3.86	--	18.52	22.38	
							200.00	2.98	--	14.30	17.28	
							200.00	2.98	--	14.30	17.28	
							200.00	2.98	--	14.30	17.28	
1 elevator	1,225.15	15	81.68	36.75	19.60	138.03	400.00	17.90	--	73.51	91.41	229.44
1 elevator	367.01	15	24.47	11.01	5.87	41.35	400.00	--	--	22.02	22.02	63.37
5 forks	58.75	5	11.75	1.76	.94	14.45	--	--	--	--	--	14.45
2 wheelbarrows	50.00	15	3.33	1.50	.80	5.63	--	--	--	--	--	5.63
2 shovels	8.00	5	1.60	.24	.13	1.97	--	--	--	--	--	1.97
Total	--	--	--	--	--	1,280.11	--	--	--	--	480.95	1,689.06
ABOVE-GROUND CROSS ALLEY—FLUMING												
100 cwt. per hour:												
1,411 ft. flumes	6,011.75	25	240.47	180.35	90.18	511.00	--	--	--	14.11	14.11	525.11
3,767 bd.-ft. flume covers	489.71	7	69.96	14.69	7.84	92.49	--	--	--	37.67	37.67	130.16
1 grating	40.00	25	1.60	1.20	.64	3.44	1,277.65	--	--	2.56	2.56	6.00
1 pump and motor	532.00	15	35.47	15.96	8.51	59.94	1,277.65	41.92	113.31	50.98	206.21	266.15
1 set steel plumbing	157.77	25	6.31	4.73	2.52	13.56	1,277.65	--	--	10.08	10.08	23.64
197 ft. pipe and fittings	283.16	25	11.33	8.49	4.53	24.35	1,219.70	--	--	17.27	17.27	41.62
30 ft. rubber coil hose	139.20	10	13.92	4.18	2.23	20.33	1,219.70	--	--	8.49	8.49	28.82
2 gate valves	88.00	15	5.87	2.64	1.41	9.92	1,277.65	--	--	5.62	5.62	15.54
252 ft.^{2} sump	504.00	25	20.16	15.12	7.56	42.84	1,277.65	--	--	32.20	32.20	75.04
1 elevator	615.25	15	41.02	18.46	9.84	69.32	1,200.00	14.76	--	110.75	125.51	194.83
Total	--	--	--	--	--	847.19	--	--	--	--	459.72	1,306.91
200 cwt. per hour:												
1,411 ft. flumes	6,011.75	25	240.47	180.35	90.18	511.00	--	--	--	14.11	14.11	525.11
3,767 bd.-ft. flume covers	489.71	7	69.96	14.69	7.84	92.49	--	--	--	37.67	37.67	130.16
1 grating	40.00	25	1.60	1.20	.64	3.44	647.70		--	1.29	1.29	4.73
1 pump and motor	765.00	15	51.00	22.95	12.25	86.19	647.70	48.30	85.18	37.16	170.64	256.83
1 set steel plumbing	206.11	25	8.24	6.18	3.30	17.72	647.70	--	--	6.67	6.67	24.39
197 ft. pipe and fittings	361.68	25	14.47	10.85	5.79	31.11	609.85	--	--	11.03	11.03	42.14
30 ft. rubber coil hose	154.50	10	15.45	4.64	2.47	22.56	609.85	--	--	4.71	4.71	27.27
2 gate valves	109.00	15	7.27	3.27	1.74	12.28	647.70	--	--	3.53	3.53	15.81
252 ft.^{2} sump	504.00	25	20.16	15.12	7.56	42.84	647.70		--	16.32	16.32	59.16
1 elevator	856.00	15	57.07	25.68	13.70	96.45	600.00	8.95	--	77.04	85.99	182.44
Total	--	--	--	--	--	916.08	--	--	--	--	351.96	1,268.04

TABLE 17.—*Ownership and operating costs for potato handling equipment of annual volume of 120,000 cwt., by specified type of storage and handling system*—Continued

Supply rate and amount of equipment	Initial cost	Estimated life	Ownership cost: Depreciation	Ownership cost: Interest	Ownership cost: Insurance and taxes	Ownership cost: Total	Hours of operation	Operating cost: Power	Operating cost: Water	Operating cost: Maintenance	Operating cost: Total	Total annual cost
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
					ABOVE-GROUND CROSS ALLEY—FLUMING—Continued							
300 cwt. per hour:												
1,411 ft. flumes	6,011.75	25	240.47	180.35	90.18	511.00	--	--	--	14.11	14.11	525.11
3,767 bd.-ft. flume covers	489.71	7	69.96	14.69	7.84	92.49		--	--	37.67	37.67	130.16
1 grating	40.00	25	1.60	1.20	.64	3.44	430.85	--	--	.86	.86	4.30
1 pump and motor	858.00	15	57.20	25.74	13.73	96.68	430.85	48.19	80.65	27.73	156.57	253.25
1 set steel plumbing	250.33	25	10.01	7.51	4.00	21.52	430.85	--	--	5.39	5.39	26.91
197 ft. pipe and fittings	458.60	25	18.34	13.76	7.34	39.43	406.57	--	--	9.32	9.32	48.75
30 ft. rubber coil hose	233.40	10	23.34	7.00	3.73	34.07	406.57	--	--	4.74	4.74	38.81
2 gate valves	131.00	15	8.73	3.93	2.10	14.76	430.85	--	--	2.82	2.82	17.58
259 ft.² sump	518.00	25	20.72	15.54	7.77	44.03	430.85	--	--	11.16	11.16	55.19
1 elevator	984.40	15	65.63	29.53	15.75	110.91	400.00	11.93	--	59.06	70.99	181.90
Total	--	--	--	--	--	968.33	--	--	--		313.63	1,281.96
					ABOVE GROUND DOOR-PER-BIN—FLUMING							
100 cwt. per hour:												
1,474.5 ft. flumes	6,371.25	25	254.85	191.14	95.57	541.56	--	--	--	14.74	14.74	556.30
3,937 bd.-ft. flume covers	511.81	7	73.12	15.35	8.19	96.66	--	--	--	39.37	39.37	136.03
1 grating	40.00	25	1.60	1.20	.64	3.44	1,293.30	--	--	2.59	2.59	6.03
1 pump and motor	532.00	15	35.47	15.96	8.51	59.94	1,293.30	42.43	122.00	51.60	216.03	275.97
1 set steel plumbing	156.33	25	6.25	4.69	2.50	13.44	1,293.30	--	--	10.11	10.11	23.55
263 ft. pipe and fittings	379.07	25	15.16	11.37	6.07	32.60	1,226.65	--	--	23.25	23.25	55.85
30 ft. rubber coil hose	139.20	10	13.92	4.18	2.23	20.33	1,226.65	--	--	8.54	8.54	28.87
2 gate valves	88.00	15	5.87	2.64	1.40	9.91	1,293.30	--	--	5.69	5.69	15.60
336 ft.² sump	672.00	25	26.88	20.16	10.08	57.12	1,293.30	--	--	43.45	43.45	100.57
1 elevator	654.84	15	43.66	19.65	10.48	73.79	1,200.00	14.76	--	117.87	132.63	206.42
Total	--	--	--	--	--	908.79	--	--	--		496.40	1,405.19
200 cwt. per hour:												
1,474.5 ft. flumes	6,371.25	25	254.85	191.14	95.57	541.56	--	--	--	14.74	14.74	556.30
3,937 bd.-ft. flume covers	511.81	7	73.12	15.35	8.19	96.66	--	--	--	39.37	39.37	136.03
1 grating	40.00	25	1.60	1.20	.64	3.44	653.34	--	--	1.31	1.31	4.75
1 pump and motor	765.00	15	51.00	22.95	12.24	86.19	653.34	48.72	89.10	37.48	175.30	261.49
1 set steel plumbing	247.41	25	9.90	7.42	3.96	21.28	653.34	--	--	8.08	8.08	29.36
263 ft. pipe and fittings	483.69	25	19.35	14.51	7.74	41.60	613.32	--	--	14.83	14.83	56.43
30 ft. rubber coil hose	154.50	10	15.45	4.64	2.47	22.56	613.32	--	--	4.74	4.74	27.30

2 gate valves	131.00	15	8.73	3.93	2.10	14.76	653.34	--	--	4.28	4.28	19.04
336 ft.² sump	672.00	25	26.88	20.16	10.08	57.12	653.34	--	--	21.95	21.95	79.07
1 elevator	904.15	15	60.28	27.12	14.47	101.87	600.00	8.95	--	81.37	90.32	192.19
Total	--	--	--	--	--	987.04	--	--	--	--	374.92	1,361.96
300 cwt. per hour:												
1,474.5 ft. flumes	6,371.25	25	254.85	191.14	95.57	541.56	--	--	--	14.74	14.74	556.30
3,937 bd.-ft. flume covers	511.81	7	73.12	15.35	8.19	96.66	--	--	--	39.37	39.37	136.03
1 grating	40.00	25	1.60	1.20	.64	3.44	434.05	--	--	.87	.87	4.31
1 pump and motor	858.00	15	57.20	25.74	13.23	96.17	434.05	48.55	84.61	27.93	161.09	257.26
1 set steel plumbing	247.41	25	9.90	7.42	3.96	21.28	434.05	--	--	5.37	5.37	26.65
263 ft. pipe and fittings	610.37	25	24.41	18.31	9.77	52.49	408.88	--	--	12.48	12.48	64.97
30 ft. rubber coil hose	233.40	10	23.34	7.00	3.73	34.07	408.88	--	--	4.77	4.77	38.84
2 gate valves	131.00	15	8.73	3.93	2.10	14.76	434.05	--	--	2.84	2.84	17.60
336 ft.² sump	672.00	25	26.88	20.16	10.08	57.12	434.05	--	--	14.58	14.58	71.70
1 elevator	1,045.39	15	69.69	31.36	16.73	117.78	400.00	11.93	--	62.72	74.65	192.43
Total	--	--	--	--	--	1,035.33	--	--	--	--	330.76	1,366.09
BELOW-GROUND DEEP BIN—FLUMING												
100 cwt. per hour:												
1,627 ft. flumes	6,914.75	25	276.59	207.44	103.72	587.75	--	--	--	16.27	16.27	604.02
4,344 bd.-ft. flume covers	564.72	7	80.67	16.94	9.04	106.65	--	--	--	43.44	43.44	150.09
1 grating	40.00	25	1.60	1.20	.64	3.44	1,270.65	--	--	2.54	2.54	5.98
1 pump and motor	532.00	15	35.47	15.96	8.51	59.94	1,270.65	41.69	108.06	50.70	200.45	260.39
1 set steel plumbing	156.97	25	6.28	4.71	2.51	13.50	1,270.65	--	--	9.97	9.97	23.47
155 ft. pipe and fittings	255.07	25	10.20	7.65	4.08	21.93	1,216.65	--	--	15.52	15.52	37.45
30 ft. rubber coil hose	139.20	10	13.92	4.18	2.23	20.33	1,216.65	--	--	8.47	8.47	28.80
2 gate valves	88.00	15	5.87	2.64	1.40	9.91	1,270.65	--	--	5.59	5.59	15.50
210 ft.² sump	420.00	25	16.80	12.60	6.30	35.70	1,270.65	--	--	26.68	26.68	62.38
1 elevator	876.33	15	58.42	26.29	14.02	98.73	1,200.00	29.53	--	157.74	187.27	286.00
1 elevator	277.13	15	18.48	8.31	4.43	31.22	1,200.00	--	--	49.88	49.88	81.10
Total	--	--	--	--	--	989.10	--	--	--		566.08	1,555.18
200 cwt. per hour:												
1,627 ft. flumes	6,914.75	25	276.59	207.44	103.72	587.75	--	--	--	16.27	16.27	604.02
4,344 bd.-ft. flume covers	564.72	7	80.67	16.94	9.04	106.65	--	--	--	43.44	43.44	150.09
1 grating	40.00	25	1.60	1.20	.64	3.44	645.20	--	--	1.29	1.29	4.73
1 pump and motor	765.00	15	51.00	22.95	12.24	86.19	645.20	48.11	82.76	37.01	167.88	254.07
1 set steel plumbing	204.52	25	8.18	6.14	3.27	17.59	645.20	--	--	6.60	6.60	24.19
155 ft. pipe and fittings	323.34	25	12.93	9.70	5.17	27.80	608.32	--	--	9.83	9.83	37.63
30 ft. rubber coil hose	154.50	10	15.45	4.64	2.47	22.56	608.32	--	--	4.70	4.70	27.26
2 gate valves	109.00	15	7.27	3.27	1.74	12.28	645.20	--	--	3.52	3.52	15.80
210 ft.² sump	420.00	25	16.80	12.60	6.30	35.70	645.20	--	--	13.55	13.55	49.25
1 elevator	1,043.25	15	69.55	31.30	16.69	117.54	600.00	17.90	--	93.89	111.79	229.33
1 elevator	315.65	15	21.04	9.47	5.05	35.56	600.00	--	--	28.41	28.41	63.97
Total	--	--	--	--	--	1,053.06			--		407.28	1,460.34

TABLE 17.—*Ownership and operating costs for potato handling equipment of annual volume of 120,000 cwt., by specified type of storage and handling system*—Continued

Supply rate and amount of equipment	Initial cost	Estimated life	Ownership cost: Depreciation	Ownership cost: Interest	Ownership cost: Insurance and taxes	Ownership cost: Total	Hours of operation	Operating cost: Power	Operating cost: Water	Operating cost: Maintenance	Operating cost: Total	Total annual cost
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
BELOW GROUND DEEP BIN—FLUMING—Continued												
300 cwt. per hour:												
1,627 ft. flumes	6,914.75	25	276.59	207.44	103.72	587.75	--	--	--	16.27	16.27	604.02
4,344 bd.-ft. flume covers	564.72	7	80.67	16.94	9.04	106.65		--	--	43.44	43.44	150.09
1 grating	40.00	25	1.60	1.20	.64	3.44	429.31	--	--	.86	.86	4.30
1 pump and motor	858.00	15	57.20	25.74	13.73	96.67	429.31	48.02	78.62	27.63	154.27	250.94
1 set steel plumbing	248.72	25	9.95	7.46	3.98	21.39	429.31	--	--	5.34	5.34	26.73
155 ft. pipe and fittings	407.36	25	16.29	12.22	6.52	35.03	405.55	--	--	8.26	8.26	43.29
30 ft. rubber coil hose	233.40	10	23.34	7.00	3.73	34.07	405.55	--	--	4.73	4.73	38.80
2 gate valves	131.00	15	8.73	3.93	2.10	14.76	429.31	--	--	2.81	2.81	17.57
223 ft.² sump	446.00	25	17.84	13.38	6.69	37.91	429.31	--	--	9.57	9.57	47.48
1 elevator	1,265.81	15	84.39	37.97	20.25	142.61	400.00	17.90	--	75.95	93.85	236.46
1 elevator	367.01	15	24.47	11.01	5.87	41.35	400.00	--	--	22.02	22.02	63.37
Total	--	--	--	--	--	1,121.63		--	--		361.42	1,483.05
ABOVE-GROUND CROSS ALLEY—BULK SCOOPING												
100 cwt. per hour:												
1 powered bulk scoop	4,280.00	15	285.33	128.40	68.48	482.21	229.81	--	103.41	196.72	300.13	782.34
1 uniform feed hopper	835.00	15	55.67	25.05	13.36	94.08	1,200.00	9.84	--	100.20	110.04	204.12
1 elevator	277.13	15	18.48	8.31	4.43	31.22	1,200.00	--	--	49.88	49.88	81.10
2 LP gas bottles	136.00	20	6.80	4.08	2.18	13.06		--	--			13.06
Total	--	--	--			620.57			--		460.05	1,080.62
200 cwt. per hour:												
1 powered bulk scoop	4,280.00	15	285.33	128.40	68.48	482.21	229.81	--	103.41	196.72	300.13	782.34
1 uniform feed hopper	835.00	15	55.67	25.05	13.36	94.08	600.00	6.71	--	50.10	56.81	150.89
1 elevator	315.65	15	21.04	9.47	5.05	35.56	600.00	--	--	28.41	28.41	63.97
2 LP gas bottles	136.00	20	6.80	4.08	2.18	13.06		--	--			13.06
Total	--	--	--	--		624.91	--	--	--	--	385.35	1,010.26
300 cwt. per hour:												
1 powered bulk scoop	4,280.00	15	285.33	128.40	68.48	482.21	229.81	--	103.41	196.72	300.13	782.34
1 uniform feed hopper	835.00	15	55.67	25.05	13.36	94.08	400.00	5.97		33.40	39.37	133.45
1 elevator	367.01	15	24.47	11.01	5.87	41.35	400.00	--	--	22.02	22.02	63.37
2 LP gas bottles	136.00	20	6.80	4.08	2.18	13.06			--			13.06
Total	--	--	--	--		630.70	--	--	--	--	361.52	992.22

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